RADIO and ELECTRONICS

Vol. 5, No. 12 — February 1st, 1951

Page

OUR COVER

This month's picture shows one of the relay transmitters used by the B.B.C. at Calais for their recent cross-channel broadcast of a television programme originating in France.

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The Application of Electronics to Industry

Electronics is a powerful, but comparatively new, tool, which is finding ever-increasing applications in industry, and it is to be hoped that it will continue to do so. There is, however, one particularly important feature of electronic equipment that may retard, rather than increase its usefulness, unless the designers of electronic devices give it more than passing thought. We refer to the question of reliability. Competent engineers realize that in a sense, electronics has grown up too quickly, and in some degree has even over-reached itself a little. The very fact that many things are more easily done electronically than by other means, together with the ability of electronics to do many more things that cannot be done at all otherwise, has tended to make some workers think that electronics is a panacea or a kind of philosophers' stone. For just as many jobs can be done only by electronics, so too, many more hold no possible application for it. But it is not in either of these categories that the danger lies. It is in a third class of problems, which can be solved either by electronics, or by purely electrical or mechanical means, that electronic designers and engineers must exercise caution. These problems must be examined very carefully, as to cost, reliability, and ease of maintenance, before a decision is made for or against the electronic method. In many cases, first cost can actually be lower when the electronic solution is chosen, but cost may be quite unimportant compared with reliability. There are very few engineering projects where reliability is not of paramount importance, and it is here that responsible engineers have to think twice about the use of valve-operated equipment.

It is an unfortunate thing, but a true one, that many of the fundamental processes upon which electron tubes rely for their manufacture or operation are still not properly understood. For instance, the exact mechanism by which electrons are made available by a cathode is still a matter for argument among physicists. Now this may not at first sight appear to have much to do with the reliability of vacuum tubes, but it has. For the most part our valves rely for their supply of electrons on composite cathode materials which are difficult to make, are very easily "poisoned" by minute amounts of impurities, and which even depend for their success on minute traces of other "impurities" whose role is not properly understood. Present-day valves are thus rendered more difficult to apply, because the cathode materials in use are sensitive, among other things, to the exact temperature at which they are run. In equipment which must be as reliable as possible, therefore, it becomes necessary to use controlling devices which regulate the voltage fed to the valve heaters, in order to maintain them at the right temperature. There is always the temptation to do without voltage control, cheapening the product, and possibly reducing its reliability below the level that is really required. Who knows but that a fuller fundamental understanding of electron emission may not lead to the development of cathodes whose heating is so uncritical as to make voltage control unnecessary, even for the best equipment?

This is merely one example of how increased knowledge could make electronic gear more dependable. But we have to work with the valves that exist, not with the improved ones the makers of such things hope to develop. What, then, can we do to see that dependability is improved?

An analysis of failure in the field has shown that there are three major causes of unserviceability in valve-operated equipment. They are (1) the use of valves when some other device would have been more suitable; (2) the failure to select the best valve for the particular application; and (3) actual errors in design of the equipment, and the inadequate provision of protective devices which could prevent a breakdown of the complete equipment.

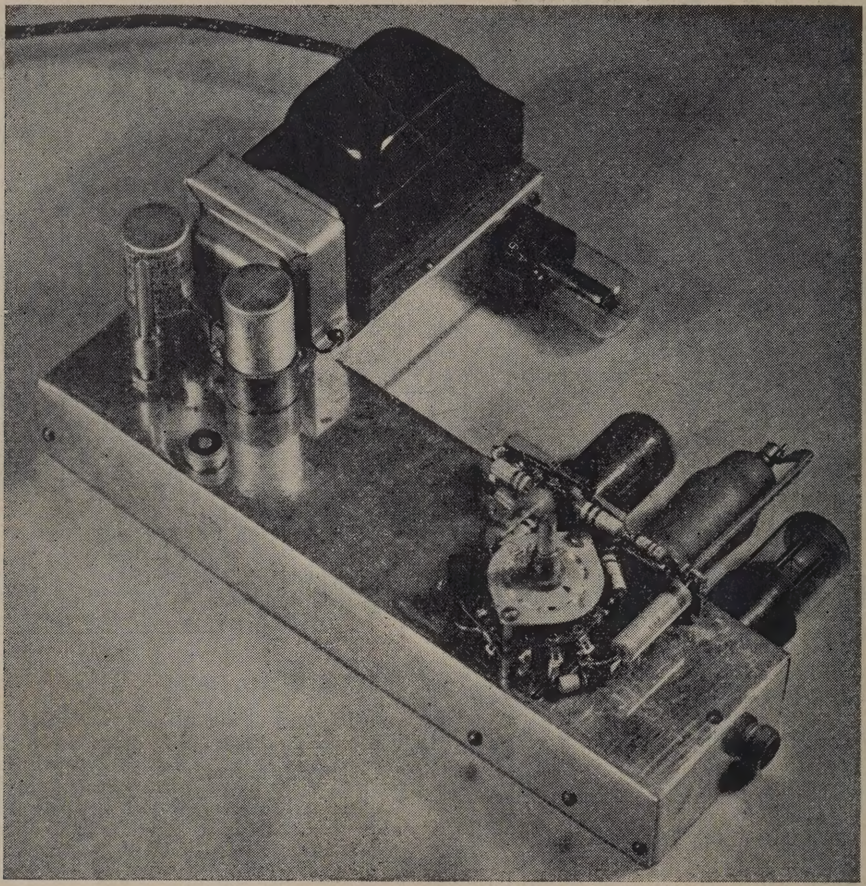
It can be seen, therefore, that the design engineer can do a great deal to improve reliability. In the first place, he must ask himself whether a valve is needed, and if so, why. If the answer to this question is in the affirmative, he must investigate the possibilities should the valve fail. In many cases, failure can cause no more than inconvenience, as when the radio set goes out of action in the middle of an exciting serial, but in others, a valve failure may mean loss of property or even life. Where failures of this sort could occur, it is the designer's responsibility to make any failures "safe." In some equipment this means complete duplication, with provision for automatically bringing in the standby gear when a failure occurs, while in others, a simple alarm indicator will suffice.

It has been said that the greatest single threat to reliability is the continual pressure on the makers of tubes, by the users, to increase tubes' ratings. The opposite question—that of increasing the life expectancy of valves by working them under their ratings—is hardly ever raised, but by so doing, designers could undoubtedly save a multitude of tube failures which occur at less than the normal life expectancy of the valve concerned.

These, and many other factors all contribute to the unreliability of things electronic, but no discussion of the problem would be complete that does not mention the question of maintenance. Here, education is necessary, not only for the designer, in the way he should go, but for the user, who should know how frequently routine inspections should be carried out, especially in the case of equipment on whose operation life and property depend. Lastly, there is education for those whose direct responsibility the maintenance will be. The equipment itself, or its designer, cannot be blamed for failure which is due to improper maintenance but it is none the less in the interests of the producer of electronic goods to see that the users of his products have a proper appreciation of the maintenance that is required.

The "R. and E." Gramophone Pre-amplifier

Although relatively complicated, the pre-amplifier described in this article fulfils practically all the possible requirements of such a device, and, in addition, has been built in a very unconventional manner so as to be suitable for mounting under the motor-board in any electric gramophone.



INTRODUCTION

Although there has lately been rather a spate of circuits designed for pre-amplification and tone-compensation with modern lightweight gramophone pick-ups, the constructor whose forte is the reproduction of gramophone records has been left somewhat in the air over the whole thing. What we mean by this is that every now and again a "new" circuit is presented in the literature for performing one of the necessary functions of a gramophone pre-amplifier, or perhaps even several of them. The quality enthusiast reads, is impressed, and decides that he would like to incorporate something of a similar nature in his own gear, but on investigating further, he finds that either the valves used are not available to him, or the line-up suggested does not fit in by any means with what he has at present. This means either using different valves, with not much idea whether the replacements will give the same performance as the original ones, or even rebuilding his whole amplifier in order to incorporate the new circuit details. Also, very little is usually given about the construction of such things. Sometimes, they amount to several valves, and the builder only finds out by bitter experience that when these are attached to the main amplifier's power supply, the whole thing oscillates violently, and nothing he can do will make it behave properly.

The present article is therefore designed to describe a pre-amplifier that will do almost anything that requires doing, will be able to be attached to any main amplifier without trouble of any sort, and will work satisfactorily from any of the modern light-weight medium-output pick-ups that have become so popular of late. In addition, it is so designed physically that it can be mounted under the motor-board in any existing radio-gram or turntable unit without getting in the way of the motor. Also, the controls are brought out at the top of the chassis, so that they can come through the motor board beside the turntable and do not have to appear on the front of the cabinet.

WHAT THE PRE-AMPLIFIER WILL DO

When one uses any of the modern high-quality pick-ups, it is first and foremost essential to insert an equalizing circuit whose job it is to make the low-frequency response of the pick-up/record combination flat. The response of the pick-up itself is flat, but the response of the record drops off at a rate of 6 db. per octave below 250 to 300 c/sec., and it is this drop that has to be compensated. Needless to say, this is the first function of the pre-amplifier presented here. The equalization can be and in fact is produced by a simple circuit containing only resistance and capacity, but in the process, this network manages to cause a loss in output voltage to about a tenth of the original figure, so that one stage of amplification is needed in order to overcome this loss.

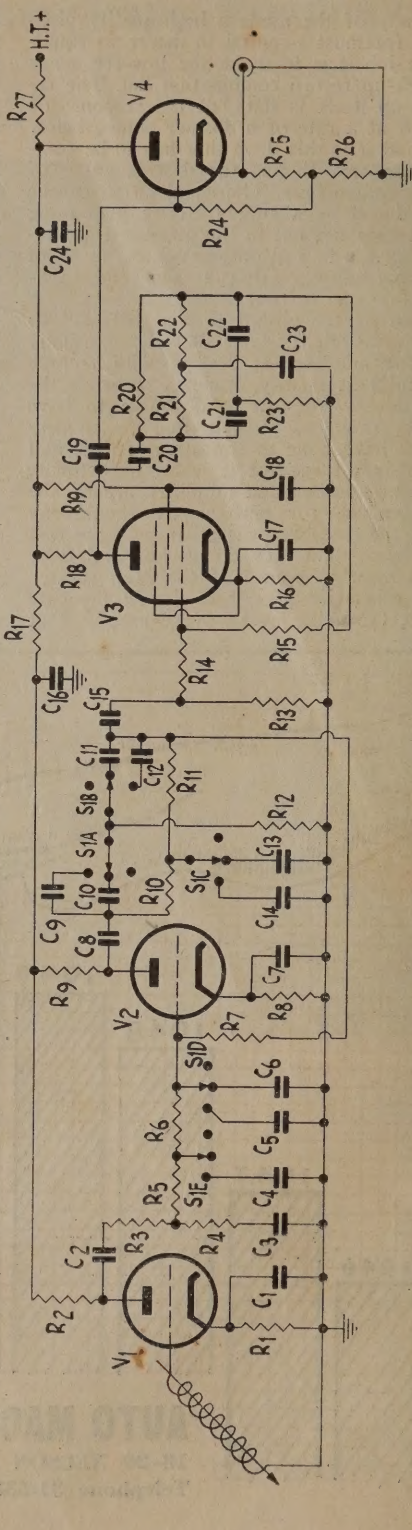
The next function of the circuit is one that will be found very useful, although it is one that is not usually employed. When our amplifier is dealing with records of the brightest and best quality, such as some of the more recent high-fidelity ones, it is desirable to have as wide a frequency range as possible, and the chances are that most of us have gone to considerable time and expense to achieve just this. But it is an unfortunate fact that even if our speaker and amplifier are of the most superb performance (or perhaps we should say *especially* if this is the case) records other than the best frequently sound worse than they do on less ambitious equipment. This is mostly because of the high scratch level possessed by otherwise good records. In the case of the best records, the noise level is very low, so that we can take full advantage of their extended high-frequency response, ignoring the small amount of noise that remains. But there are a multitude of records which, while excellent musically and even technically also, are marred by a high scratch level. When these are played through "ordinary" equipment, which produces very little if anything above, say, 5000 c/sec., the surface noise is not so objectionable as to make them useless, but played on extended range equipment, and in comparison with really good records, they sound very poor indeed. It thus becomes advisable to have some means of limiting the high-frequency response of the whole system so that we can get acceptable results from poorer records.

The commonest way of doing this is to use the common or garden 'tone-control." This is an inexpensive way out, but one which, from the point of view of getting the best out of the recordings one has, is not at all to be recommended. The trouble is that any ordinary tone-control circuit causes a large loss of frequencies much lower than one wants to lose, especially if it is adjusted so as to give any worth-while reduction in the amount of surface noise. It seems to be fairly well established now among the audio pundits that the best way to combat surface noise is by the use of a low-pass filter with a sharp cut-off. This has the effect of removing completely all frequencies above the cut-off frequency, while allowing all frequencies below this frequency to pass as well as ever. Such a characteristic can never be obtained by simple tone control circuits

which, if effective in reducing scratch, make the reproduction sound "wooffy" and muffled. A proper low-pass filter, on the other hand, works so as to be as effective as possible in removing scratch, while at the same time only slightly reducing the brilliance of the reproduction. Many older recordings were made before anything better than 7 or 8000 c/sec. was recorded, so that it can be seen that extending the frequency range of the playing equipment in such a case adds absolutely nothing to the music, but a great deal to the surface noise. Other records will sound much better if a slight sacrifice in high frequencies is made in favour of a large reduction in the scratch. Unlike the tone control, as ordinarily used, the low-pass filter enables this to be done very effectively. Assuming that this is so, there arises the question of what the cut-off frequency should be. This really depends on the individual record to be played, so that an ideal system would have a sharp cut-off filter with the cut-off frequency continuously variable. Such a filter could no doubt be made, but it would be an exceedingly difficult and costly thing to design and build, so that in practice, we must put up with a number of separate filters, with different cut-off frequencies, which may be switched into the circuit at any time, to suit the record that is being played. In the present circuit we have compromised with two filters, and a straight-through position, which has no filter in circuit. The cut-off frequencies of the filters are 5000 and 10,000 c/sec. respectively. It might be an advantage to have an additional filter cutting off at 7000 c/sec., but for the extra trouble involved in providing it, it is hardly thought to be worth while.

Until comparatively recently, sharp-cut-off filters like this were almost impossible to use in ordinary equipment, because they had to be made from inductance and capacity, and were complicated, but with the introduction of methods of making high- and low-pass filters with the aid of only resistors and condensers, assisted by amplifier valves, it is possible to produce the results of costly L/C filters with relatively simple circuitry that is inexpensive to build. One valve is necessary for the low-pass filter circuit, which has an overall gain of little more than unity. Thus, the first two valves, the triodes, do very little more than prevent the rest of the circuitry from giving a large loss of signal voltage. There is actually a gain of approximately 1.5 times over the first two stages. The next valve is a pentode, working under conditions which give it a gain of about 15 times, so that the overall gain of the circuit is approximately 22.5 times. Thus, for the average lightweight pick-up with an output of 200 millivolts, the output of the pre-amplifier will be about 2¼ volts. This is more than enough to load most main amplifiers fully, since the latter are usually arranged to load fully off 0.5 volts or less.

The last valve in the chain is one half of a further 6SN7, used as a cathode follower output coupling valve. Since the pre-amplifier unit will almost always be several feet from the main amplifier, it is very desirable to have the output of the former fed from a low-impedance source. This ensures that a shielded lead, which may be necessary to prevent the pick-up of hum by the output lead, will not at the same time cause an undesirable loss in high frequencies, and at the same time it greatly reduces the likelihood of hum pick-up occurring in any case. The output level of 2 volts or so makes it very unlikely that the high heater-cathode voltage of the cathode follower valve will introduce hum itself.



$V_1 + V_2$, 6SN7-GT
V_3, EF37 or EF37A
V_4, ½ 6SN7-GT
R_1, R_8, R_{25}, 2k.
R_2, R_5, R_9, R_{18}, 100k.
R_3, R_{13}, R_{14}, R_{19}, 250k.
R_4, 20k.
R_6, R_7, R_{24}, 500k.
R_{10}, R_{11}, 100k. 1% (or matched)
R_{12}, 50k. 1%
R_{15}, 5 meg. 5 %.
R_{16}, 1.5k.
R_{17}, R_{26}, R_{27}, 50k.
R_{20}, 10 meg. 5%
R_{21}, R_{22}, 2 meg. 1% (or matched)
R_{23}, 1 meg. 1%
C_1, C_7, C_{17} 25 μf. 25v. electro.
C_2, C_8, C_{15}, 0.1μf.
C_3, 0.05μ. 5%
C_4, 500 μμf. 5%
C_5, 250 μμf. 5%
C_6, 50 μμf. 5%
C_9, C_{12}, C_{13}, 200 μμf. 5%
C_{10}, C_{11}, 100 μμf. 5%
C_{14}, 400 μμf. 5%
C_{16}, C_{24}, 8 μf., 450v. electro.
C_{18}, 0.25 μf.
C_{19}, 0.01 μf.
C_{20}, 0.05 μf.
C_{21}, C_{22}, 0.005 μf. 2%
C_{23}, 0.01 μf. 2%

THE CIRCUIT

The complete circuit diagram, given here, looks rather complicated, and perhaps it is a little so, but there is nothing about it that need cause the intending constructor any concern. The low overall gain makes it very unlikely that trouble will be experienced through feed-back and oscillation, and the use of a separate power supply eliminates altogether the possibility of instability when the pre-amplifier is attached to the main amplifier. As the photographs show, the type of construction used is most unconventional, and the circuit has been built in a very compact form indeed. This in itself shows that instability difficulties will not be present, for with such a crowded lay-out of small parts, it would certainly show up were there an inherent tendency to oscillation, due to faulty circuit design or unsuitable lay-out.

First in the chain, V_1 is one section of the 6SN7. The pick-up is fed straight to the grid of this valve, and the pick-up winding itself acts as the grid return for the valve. R_1 and R_2 are the normal bias and plate load resistors respectively, and C_2 is a large coupling condenser whose job is only the usual one of blocking the D.C. plate voltage from the succeeding circuit. The first portion of the frequency-compensating circuit comprises

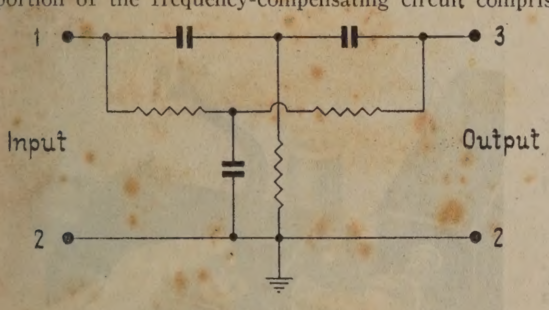


Fig. 1

R_3, R_4, and C_3. This is the official bass-boost network, which provides the rise in response below 250 c/sec. that was mentioned above. It can readily be seen that the valve V_1 amplifies the pick-up's output voltage in the normal way by a factor of approximately 14 times—the normal amplification of a section of a 6SN7 with a 100k. plate load. At middle and high frequencies, the condenser C_3 has a very small impedance, and can be regarded as virtually a short-circuit to these audio frequencies. Thus, the two resistors R_3 and R_4 act at middle and high frequencies as a simple resistive voltage divider. Since their values are 200k. and 20k. respectively, they divide the output of V_1 by a factor of 11, so that the amplification between the grid of V_1 and the junction of R_3 and R_4 is $14 \div 11 = 1.27$ times.

The output from this point is supplied to the grid of V_2 through the resistors R_5 and R_6, which in certain positions of S_1 are shunted by condensers selected from C_4, C_5, and C_6. However, in the switch position which gives straight-through operation, without any low-pass filter in circuit, none of these condensers are shunted across R_5 or R_6, which are then acting purely as a series grid stopper, and have negligible effect on the frequency response. Thus, the grid network associated with V_2 is concerned with the low-pass filter circuit, which extends on the diagram from the junction of R_3 and R_4 to the output of C_{15}, following V_2. All the circuit between these points is concerned solely with producing the low-pass filter effect, except when the ganged switches are in the extreme anti-clockwise position. In this position, the circuit is modified in such a way that there is no frequency effect, but the gain is the same as when the low-pass filter is in use. How all this comes about, we will now endeavour to explain.

THE LOW-PASS FILTER CIRCUIT

At the outset, we would like to point out that the circuit ideas used in this unit are not original, but are due to D. T. N. Williamson, of Williamson Amplifier fame. Also, the low-pass filter circuit has already been described in an earlier issue of this journal—April, 1950.

The essential portion of the circuit is the network between C_8 and C_{15}. Owing to the switching, this is really three separate networks, any of which can be selected at will. Their basic form is shown in Fig. 1. This circuit is well known as one of the comparatively new selective circuits that contain only capacity and resistance. It is called a parallel-T network, because it consists of two T networks in parallel. One T is made up of two series arms which are resistors, with a shunt

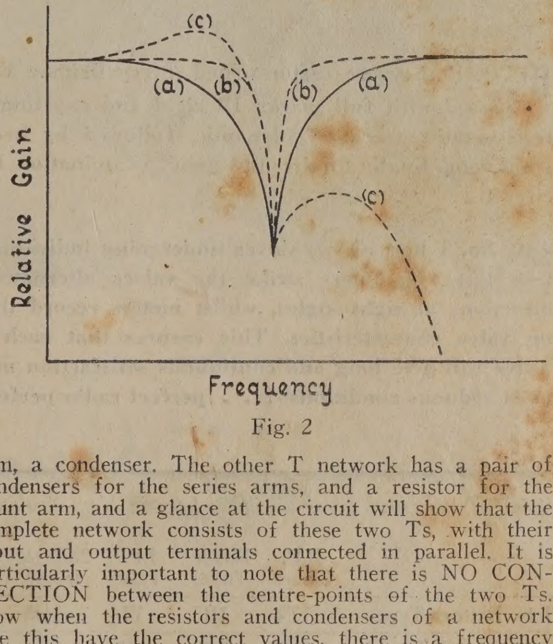


Fig. 2

arm, a condenser. The other T network has a pair of condensers for the series arms, and a resistor for the shunt arm, and a glance at the circuit will show that the complete network consists of these two Ts, with their input and output terminals connected in parallel. It is particularly important to note that there is NO CONNECTION between the centre-points of the two Ts. Now when the resistors and condensers of a network like this have the correct values, there is a frequency at which a very sharp dip occurs in the response. That is, if a variable frequency audio oscillator is fed into terminals 1 and 2, and output is taken from terminals 3 and 2, the response curve looks like that of Fig. 2A. If the values are absolutely correct, the dip is a real null and there will be no output at all at this frequency. In practice, through the tolerances in the component values, the dip is not an absolute zero output, but is still well down, being about 40 db. deep if the values are held within about two per cent. of the calculated ones.

Fig. 2 shows the response of the network itself at curve (a). One disadvantage of this curve is that after the null, the response rises once more to the same level as below the null, while a second is that the attenuation starts to become effective at frequencies much lower

than the null frequency. However, by combining the parallel-T network with a valve amplifier, both these difficulties can be overcome. First, the network is made to act as a feedback coupling network between the plate and grid of an amplifier valve. The feedback is negative, with the result that the valve adds to the selectivity of the network, and produces a much sharper null, as at (B) in Fig. 2. This overcomes the second difficulty. The first is then partly fixed by connecting a small condenser between grid and earth on the amplifier. This causes a phase shift in the feedback voltage, and gives a slight amount of positive feedback at frequencies below the null point, and extra negative feedback at frequencies above this frequency. As a result, the response curve is no longer symmetrical, but is like curve (C) on Fig. 2.

(Continued on Page 43.)

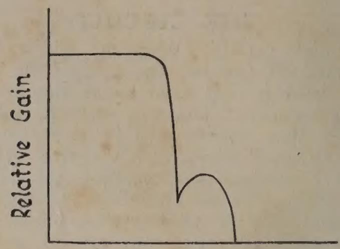


Fig. 3

An Adapter for Narrow-Band F.M. Reception

In last month's issue we presented constructional details of a narrow-band F.M. exciter for use in amateur transmitters. This month, to complete the double, we describe a simple adapter unit which can be attached to any superhet. receiver to allow the proper reception of N.B.F.M. signals.

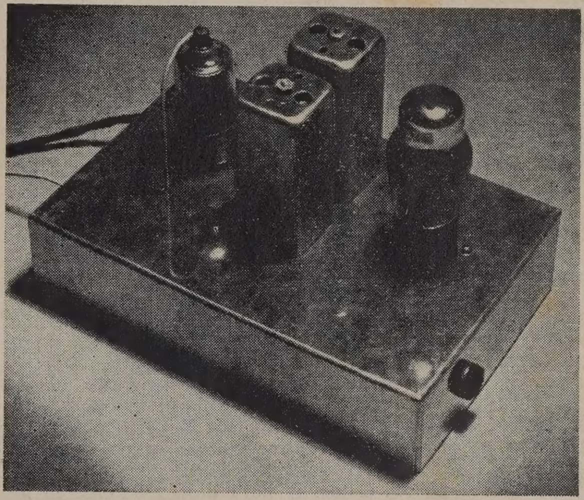
INTRODUCTION

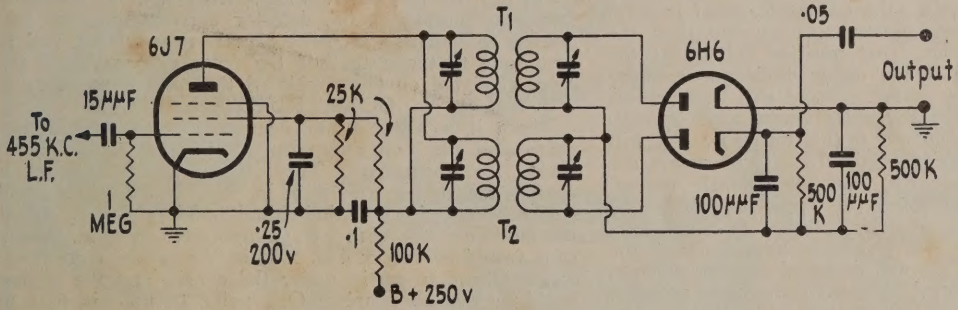
One of the difficulties attached to building a receiver suitable for F.M. reecption, whether for wide-band or narrow-band F.M., is the lack of suitable discriminator transformers which can be used in the most popular discriminator circuit—the Foster-Seeley circuit. This arrangement requires a special transformer with a centre-tapped primary winding, and a special design, in which the Q's of the primary and secondary bear a particular relationship to each other, and in which also, the coupling between primary and secondary is quite different from that found in normal I.F. transformers. Even if one is able to design such a transformer electrically, there remains the difficult problem of winding it, if the frequency is low enough to require universal-wound coils. This situation unfortunately obtains at the usual intermediate frequency of most communications receivers, whether commercial or home-built, so that for receiving narrow-band F.M. signals, the usual trick is to use an ordinary receiver, de-tuned on one side of the signal, so as to obtain the so-called slope detection, in which an F.M. signal is converted to an A.M. one by the sloping side of the selectivity curve of the I.F. channel. This scheme works, but not very well, and usually introduces quite considerable amounts of distortion. While the results may be intelligible, it is not possible under these circumstances to give the received station a worth-while report on his signals, especially as regards quality. It is therefore highly desirable to have a circuit in the receiver which can detect an F.M. signal in a proper manner. Again unfortunately, few if any receivers have this facility built into them, so that the man who wishes to receive N.B.F.M. is faced with the problem of building an adapter for his ordinary set.

This problem is similar to that of building a complete receiver for F.M., since it is only in the discriminator circuit that such a receiver differs markedly from a conventional set, at least from the first detector onwards. The present adapter has been made possible by the use of a circuit that was once popular as a frequency detector, and was used both in F.M. receivers, and as the discriminator circuit in A.F.C. systems. This circuit has the great advantage from the amateur constructor's point of view that it can be built using only standard components, and can be aligned without the use of special equipment he is unlikely to possess. The circuit of the complete unit is shown above, and it can be seen that it is quite a simple arrangement, using very few parts except the two valves and a pair of conventional 455 kc/sec. I.F. transformers.

CIRCUIT DETAILS

The idea of the adapter unit is that it should be permanently connected to the set at the input end, and provides an audio output terminal which can be plugged into the audio section of the set when F.M. reception is required. All that is necessary as far as the main receiver is concerned is to add a closed-circuit jack at the input to its audio amplifier, if such a jack is not already provided, and to provide a lead from the plate pin of the last I.F. amplifier stage to a connector somewhere on the receiver's chassis. This connector is then connected to the input terminal of the adapter by a short length of shielded lead, of as low capacity as possible. It will, of course, be necessary, after the adapter has been installed, to re-adjust the tuning of the plate circuit of the final I.F. amplifier to bring it back to resonance, but this adjustment can be done once for all, since the adapter can remain permanently connected. Since the power for the adapter is so small, it can get this from the main receiver, the requirements being 0.6 amps at 6.3 volts, for the heaters, and approximately 5 ma. at





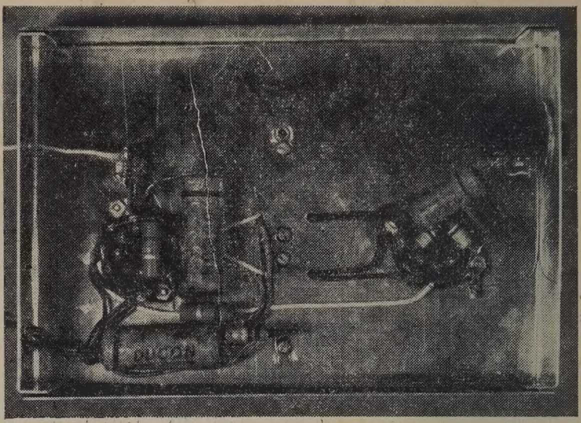
Above: View of the completed unit. Left: Circuit diagram.

250 volts, for the H.T.

The 6J7 is used as an isolating stage and an amplitude limiter. It will be noticed that it is run at zero bias, so that with the several volts of signal provided by the main set at the grid, grid current flows, and with the unusually low screen voltage, the tube acts as an efficient limiter, removing any amplitude modulation that may be present in the signal.

The most interesting part of the circuit is the discriminator, which uses the two I.F. transformers and the 6H6. These I.F. transformers are standard components, each in its own shield can, as normally used, and the photograph emphasizes this point. As the circuit diagram is drawn, one might be excused for gaining the impression that the windings of the two transformers are electromagnetically coupled together, but such is not the case, since they are shielded each from the other by their respective cans, in the ordinary way. The primary windings are, however, connected in parallel, so that half the I.F. current from the 6J7 flows through each primary. This connection does not affect their tuning, since if two tuned circuits are adjusted to the same frequency and then connected in parallel, the tuned frequency is not altered, but only the L/C ratio and the Q of the combined circuit, which becomes half the Q of each one. The secondary windings are quite independent, however, being shielded from each other, so that if they are both tuned to the I.F., each will have the same voltage output. Now each secondary winding is connected to one diode of the 6H6, and the secondaries are also connected in series. The cathode load circuits of the halves of the 6H6 are so arranged that the voltages produced by the two diodes are subtracted from each other, or, more accurately, are added algebraically. Thus, if the lower diode conducts, it produces at its cathode (which is also the output terminal) a voltage that is positive with respect to earth. But if the upper diode conducts, it produces a negative voltage at the junction of the two 500k. load resistors, and this also appears at the output terminal. Thus, if both diodes happen to be passing the same current, the two output voltages cancel out, and the voltage at the output terminal is zero. Also, if the lower diode passes more current than the upper one, there will be a net positive voltage at the output terminal, while if the upper diode passes more than the lower one, the output voltage will be negative. How, then, does this arrangement detect a frequency-modulated signal? The answer is that on its own, it will not, but if the secondaries of the I.F. transformers are tuned, not to the exact I.F., but one slightly higher, and the other slightly lower in frequency, then the arrangement will act as an F.M. detector. It is not difficult to see how this comes about. Suppose that the secondaries of T_1 and T_2 are de-tuned in this manner, and moreover are de-tuned by exactly the same amount. Both will produce an output voltage that is less than the maximum possible, if the signal is a steady one on 455 kc/sec., but because one is, say, 5 kc/sec. higher, and the other, 5 kc/sec. lower, their voltage outputs will be identical. In this case, the diodes will have identical voltage inputs, so that their D.C. outputs will be the same too, and there will be no D.C. voltage between the output terminal and earth.

Now, suppose the signal is now changed to 457 kc/sec., and remains there while we see what will happen. One secondary will now produce more volts, because the new signal is 2 kc/sec. nearer to the 460 kc/sec., to which it is tuned. The other, tuned to 450 kc/sec., will produce less output, because the signal is now farther than ever from its resonant frequency. Thus, the input to one diode is increased, and that to the other, decreased.



Under-chassis view of the unit. The output jack can be seen at the right-hand side of the chassis.

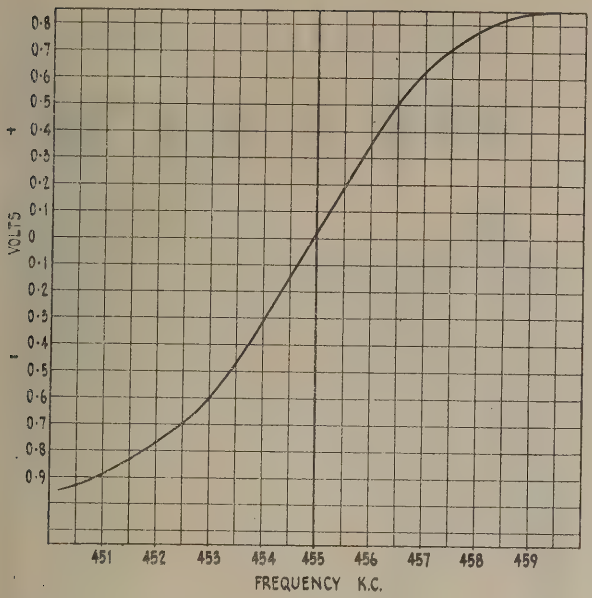
There will therefore be an output voltage from the detector, and its polarity, positive or negative, will depend only upon which diode is connected to the coil whose output has increased. If now the input frequency is changed to 453 kc/sec., the same things as before will happen, with the exception that the diode which received the larger input will now receive the smaller, and vice versa. The output voltage at the detector output terminal will thus be the same in magnitude as before, but will be reversed in polarity. We have thus seen what happens if three steady frequencies are applied to the circuit, one on the I.F., and the other two at equal distances from it on either side. If instead we present the circuit with a frequency-modulated signal, what we have just described will still happen, the only difference being that it will happen at an audio frequency rate, and with smooth transitions from one extreme of frequency to the other. Thus, there will be an audio frequency output at the detector corresponding in frequency to that at which the signal is modulated, and in amplitude to the extent of the frequency swing of the original signal on either side of the centre frequency.

CONSTRUCTION

There is so little in the adapter that the circuit diagram and the two photographs can almost be left to speak for themselves. The original was built on a chassis measuring 8 in. x 5½ in. x 1½ in., but this could easily be cut down if individual builders desire. About the minimum size with I.F. transformers in 1⅜ in. square cans would be 6 in. x 4 in. x 1½ in. As can be seen, there is very little to go in under the chasis, and the wiring could hardly be simpler. One point to note is that in the original two transformers with fixed inductances and variable condensers were used, but there is no reason why variable inductors and fixed condensers should not be used—the so-called permeability-tuned transformers, in other words. In either case, the method of adjustment will be the same, and this is the only part of the construction that needs much care to be given to it.

SETTING UP FOR USE

When the unit has been wired up and is ready for use, the first job is to install on the main receiver, the output connector and phone jack mentioned above. The adapter should be placed as close as possible to the connector on the set so that as short a lead as possible can be run to its input connecter. For aligning the adapter, it is necessary at first to take a temporary



Performance curve showing detector output voltage versus frequency of the input. Centre frequency is 455 kc/sec.

audio output from the lower half of the diode load resistor chain, that is, from the 500k. resistor connected between the cathode of the upper diode and earth. With this done, a signal at 455 kc/sec. is injected into the I.F. channel of the main set, and with the adapter fed to the input of the audio amplifier, and an output indicator attached to the output stage, the alignment of the whole I.F .section is checked over. The only thing on the set that should require adjustment is the plate winding of the last I.F. transformer, at which point the adapter is connected, detuning it somewhat. This is adjusted for maximum output in the usual way to bring it back to resonance. Then attention is turned to the adapter itself, and the first job is to align the I.F. transformers T_1 and T_2 "on the nose." With the output from only one half of the load, as described above, it is possible to tune the primary windings for maximum output. This will require an ordinary amplitude-modulated signal. First of all, one of the primary trimmers (or slugs) is set to about half way, and the paralleled primaries are brought to resonance by adusting the other trimmer or slug. The exact setting of the one that is first set to about half way does not matter at all, as long as it is such that the whole circuit can be brought to resonance by the other. This done, the secondary of T_1 is adjusted to give maximum output with the A.M. signal. Since we are using only the output from the top diode, the setting of the T_2 secondary will have no effect on this adjustment which is carried out in quite the ordinary way.

After this, the temporary output connection is re-

moved, and output is taken from the proper output terminal. The next step is to take a small condenser, of about 5 $\mu\mu$f., and temporarily connect it across the secondary of T_2. If a 5 $\mu\mu$f. condenser cannot be got, one can be made by twisting together two pieces of hook-up wire for a length of about $\frac{3}{4}$ in. Now, still with the amplitude-modulated signal into the set, the secondary of T_2 is adjusted for *minimum* output from the audio amplifier. Theoretically, this minimum should be actually zero output, but owing to slight differences between allegedly identical I.F. transformers, an actual zero will not usually be obtained. After this, no further adjustments are made to any of the transformers, and all that remains to complete the alignment is to remove the temporary small condenser from across the secondary of T_2 and place it permanently across the secondary of T_1.

It is easy to see how the above method of alignment works. When output is taken from only half the diode load, only one diode is providing output, so that an A.M. signal can be used to enable the circuits to be aligned to the I.F. by the usual method of adjusting for maximum output. After adjusting the primary, which has to be exactly on the I.F., the T_1 secondary is also adjusted to the exact I.F. Now when we take the output from the proper output terminal, both diodes are able to function, and if both secondaries are tuned exactly to the I.F., there should be no output at all. For this reason we are able to adjust the secondary of T_2 to resonance by using an A.M. signal and adjusting for minimum output. But in the finish, we want the secondaries to be slightly detuned, one on either side of the I.F., so when the T_2 secondary is being adjusted, we put a small extra capacity across it before adjusting it. Then, when this capacity is removed, the T_2 secondary will be a few kc/sec. higher in frequency than the I.F. But the secondary of T_1 is still tuned to the exact I.F., and because T_2 is higher, T_1's secondary will have to be lower by the same amount. But if we take the same small condenser, and connect it across the T_1 secondary, this winding will now be tuned slightly on the low side, as required, and because the capacity removed from the T_2 secondary is identical with that connected across the T_1 secondary, and is very small, the de-tuning of the two secondaries will be almost identical. Not quite, because the frequency of a tuned circuit is inversely proportional not to the capacity, but to its square root, but the capacity is so small that the difference is not noticeable, and the procedure outlined results in perfectly good alignment for the adapter.

The curve given on page 11 shows the actual input versus output curve for the original model. It can be seen that there is a perfectly straight portion in the centre of the curve that will give substantially distortionless reproduction of a signal that is modulated plus and minus $1\frac{1}{2}$ to 2 kc/sec. about the centre frequency. It also shows that with this order of frequency deviation, the output will approximate 0.5 volts peak, which is enough for fully loading most audio amplifiers.

TUBE DATA: RIG-BUILDER'S CIRCUIT GUIDE PART III.

CIRCUIT E

This class B modulator circuit is quite straightforward. The table gives complete operating data, including output impedance, plate to plate. Grid bias requirements are small, so that batteries may be used in most cases. Two tubes, the GL-811 and the GL-838, are zero bias tubes. In this case the C— and C+ terminals may be tied together.

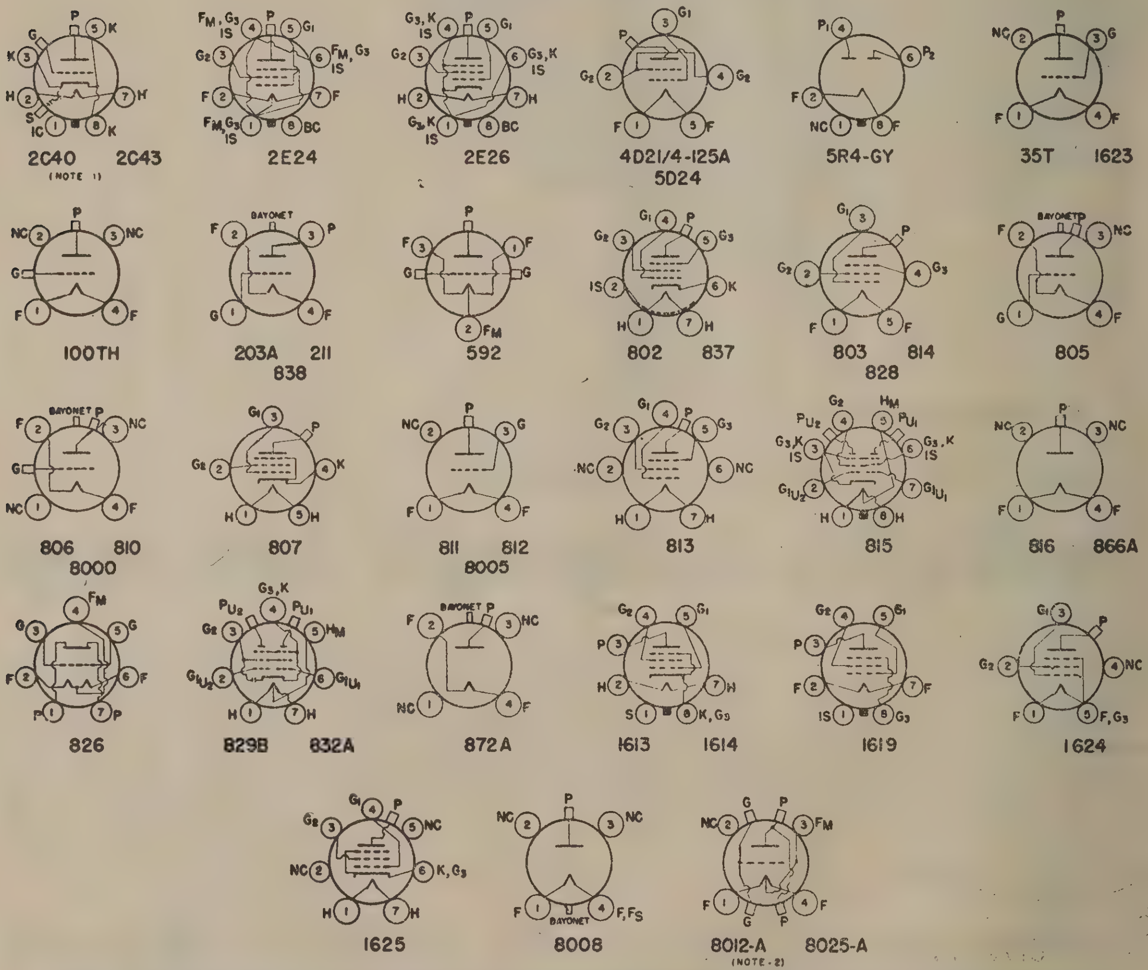
CIRCUIT F

Tetrodes, beam tubes, or pentodes may be used as class AB_2 modulators in this circuit. Both transmitting tubes and receiving tubes are included in the table. Beam tubes with an external connection for the beam-forming plates should be used with the beam-forming plates tied to the centre tap of the filament transformer. Tubes with cathodes should have the cathode grounded, and pentodes should have their suppressor grid grounded unless the table indicates otherwise.

It is necessary to use a well-regulated source of voltage for the screen-grid supply (+SG). For this reason a separate power supply is recommended. It is possible to use a voltage divider circuit, but the screen current varies so much in operation that the divider must draw a current equal to the screen-grid current. The divider is thus not economical.

SOCKET CONNECTIONS

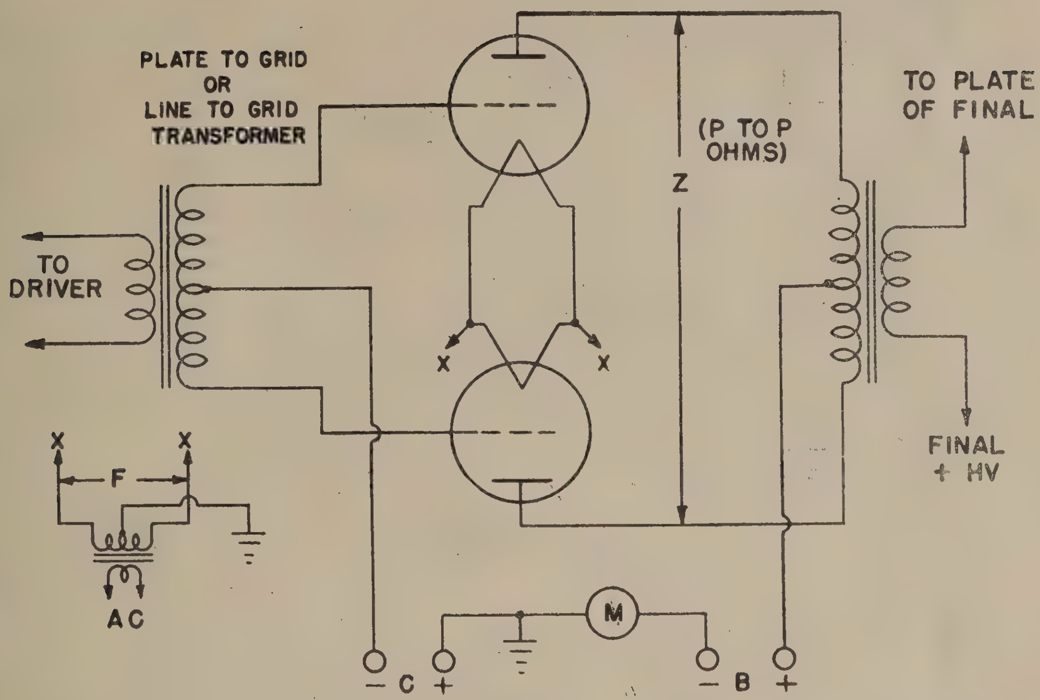
(Bottom View)



Key: BC—Base Sleeve; F—Filament: F_m—Filament center-tap; G—Grid; H—Heater; H_m—Heater center-tap; IC—Internal connection (do not use); IS—Internal shield; K—Cathode; NC—No connection; P—Plate; S—Shell; U—Unit.

Note 1: Shell is cathode r-f terminal. **Note 2: Plate caps are those farthest from base.**

CLASS B MODULATORS

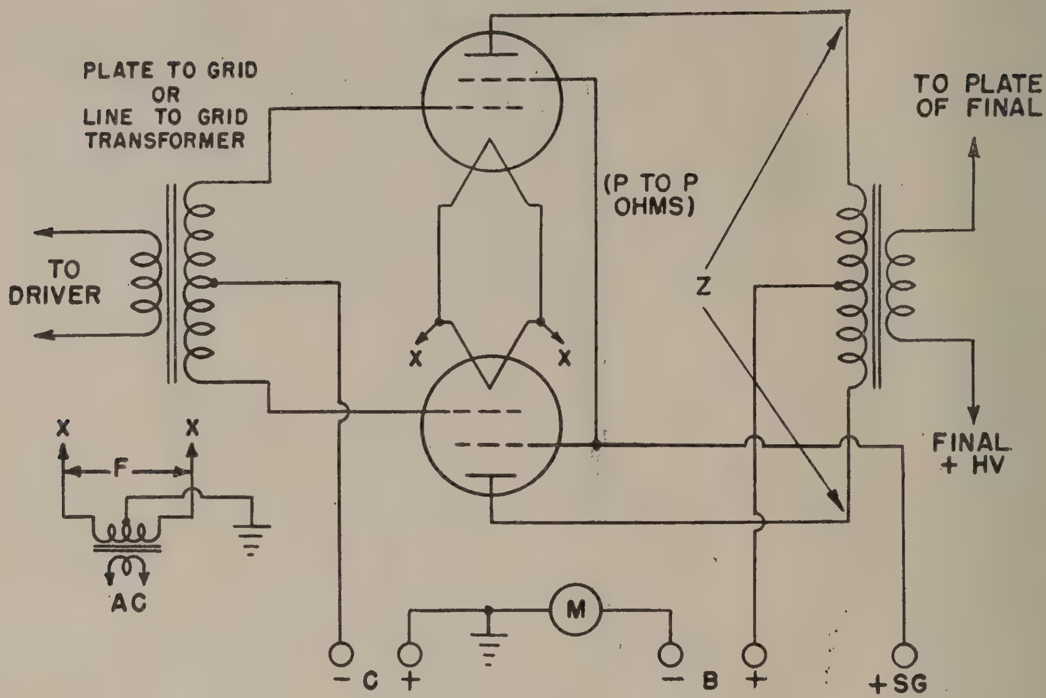


CIRCUIT E

Tube Type	F volts	Audio output watts	Driving power watts*	B	C	Zero signal I_p ma	Max. signal I_p ma	Z ohms
35T	5.0	235	4	2000	40	34	167	27,500
100TH	5.0	650	5	3000	65	40	215	31,000
203A	10.0	260	11	1250	40	26	320	9,000
211	10.0	260	8	1250	95	20	320	9,000
805	10.0	370	7	1500	16	84	400	8,200
806	5.0	535	19	2000	140	80	390	18,000
810	10.0	590	10	2000	50	60	420	11,000
811	6.3	225	4	1500	0	20	200	18,000
812	6.3	225	5	1500	46	42	200	18,000
838	10.0	260	8	1250	0	148	320	9,000
1623	6.3	145	4	1000	40	30	200	12,000
8000	10.0	600	7	2000	120	60	425	10,800
8005	10.0	300	4	1500	70	40	310	10,000

*Approximate.
All values are for two tubes.

CLASS AB2 MODULATORS



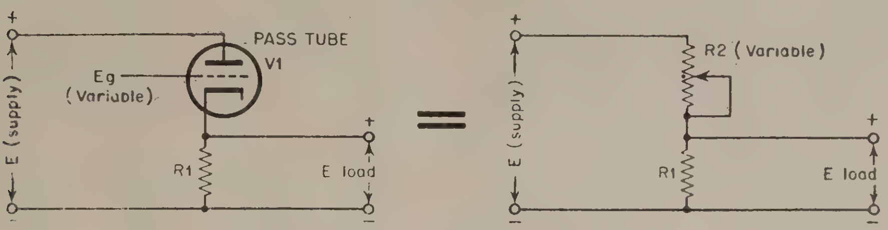
CIRCUIT F

Tube Type	F volts	Audio output watts	Peak grid power watts	B	C	SG	Max. sig. I_p ma	Max. sig. I_{sg} ma	Z ohms
2E26	6.3	54	0.36	500	15	125	150	32	8,000
4D21	5.0	520	2.5	3000	51	350	260	3.5	27,700
807*	6.3	120	0.5	750	32	300	240	10	6,960
813	10.0	515	0.1	2250	90	750	315	58	18,500
815†	6.3	54	0.36	500	15	125	150	32	8,000
828‡	10.0	385	....	2000	120	750	270	60	18,500
1619	2.5	36	0.4	400	16	300	150	11.5	6,000
1624	2.5	72	1.2	600	25	300	180	15	7,500
1625	12.6	120	0.5	750	32	300	240	10	6,960
2A5	2.5	18.5	....	375	26	250	82	19.5	10,000
42	6.3	18.5	....	375	26	250	82	19.5	10,000
6F6	6.3	18.5	....	375	26	250	82	19.5	10,000
6L6	6.3	31	....	360	18	225	142	11	6,000
6V6*	6.3	10	....	250	15	250	79	13	10,000

*Class AB_1 †Single tube operation.
‡Suppressor voltage = +60 volts.
All values are for two tubes.

REGULATED POWER SUPPLY DESIGN

By the Enginering Department, Aerovox Corporation



ILLUSTRATING ACTION OF PASS TUBE
FIG. 1

A source of well-regulated plate voltage is a prerequisite for the modern laboratory, service bench or amateur station. An ever increasing number of electronic devices, such as audio amplifiers, R.F. oscillators, amateur V.F.O.s, oscilloscopes, synchroscopes, timing circuitry, and many others, depend for their proper functioning upon a power supply which is hum free and delivers a constant voltage regardless of load. Fortunately, the development of electronically regulated sources has advanced to the state where their design and construction is well within the scope of the average user. This article outlines the theory, design, and construction of a representative supply of this type. With a firm understanding of the design principles to be discussed, the reader should be able to adapt the practical supply presented here to other requirements which might exist.

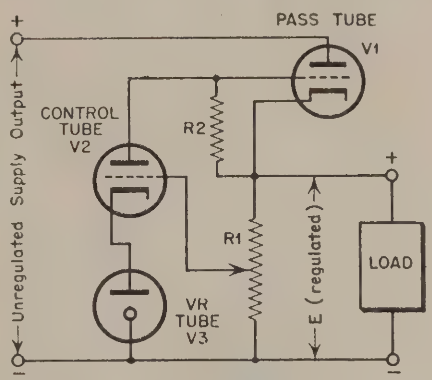
Modern regulated supplies of the type to be described make available an output voltage which is continuously variable over a considerable range and which will not vary more than a fraction of one per cent. between no-load and full-load conditions. Normal line voltage fluctuations also have little effect on output voltage. In addition, the regulation may be made of such a high order that ripple voltages in the output are almost entirely cancelled, thus eliminating the need for the usual "brute force" filter. This saving in weight and space helps to compensate for the additional complexity of the electronic regulator.

THEORY OF OPERATION

To achieve precise voltage regulation, an electronic voltage control element must be introduced in the conventional supply circuit. In most regulated supplies, this electronically variable element takes the form of a high current vacuum tube, usually called the "pass tube" or "regulator tube" in this application. This tube is connected in series with the load resistance across the output of the supply, as in Fig. 1. Since the resistance of the triode varies as a function of its grid voltage, this combination acts as an electronically controlled voltage divider. A small change in the regulator tube grid voltage changes the effective ratio of the divider and thus varies the voltage appearing across the output load.

The ability to vary the output voltage of the supply by a minute grid voltage change suggests that automatic voltage regulation could be accomplished by feeding any attempted output voltage fluctation back to this grid at such a polarity as to oppose that change. In other words, if the voltage across the load in Fig. 1 attempted to rise, the grid of the pass tube (V_1) should be made more negative so that its internal resistance would increase and lower the load voltage. If the load voltage attempted to decrease the converse action should occur.

This action is achieved by the circuit shown in simplified form in Fig. 2. Auxiliary circuitry consisting of a second vacuum tube, usually called the "control tube," and a constant voltage source such as a battery or "VR" tube is added to the circuit of Fig. 1. A sample of the output voltage is applied to the grid of the control tube by a tap on the output bleeder R_1. The control tube determines the bias on the regulator tube (V_1) since the load resistor (R_2) for the control tube is also the bias



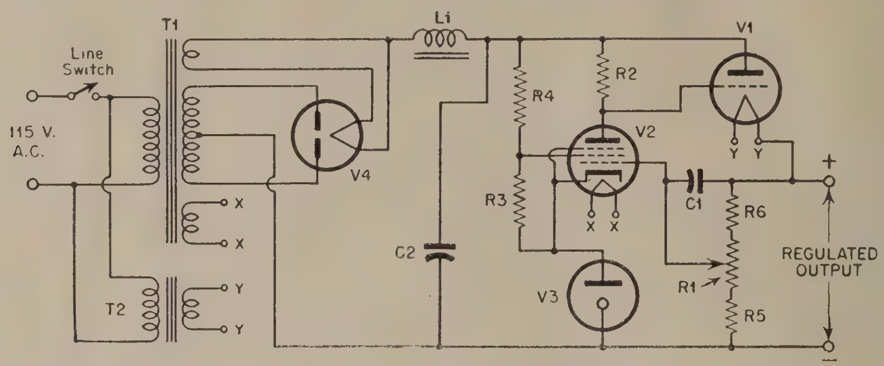
SIMPLIFIED ELECTRONIC REGULATOR
FIG. 2

resistor for the regulator tube. The control tube therefore performs two functions; it amplifies voltage fluctuations impressed upon its grid by the output circuit, and it reverses the phase of those fluctuations so that they may be applied to the grid of the pass tube in the right direction to effect regulation. The precision of the regulation attained increases with the gain of the control tube since, with greater gain, a small change in control tube grid voltage will cause a greater control tube current change and hence a greater change in pass tube bias. Thus, smaller attempted output volatge excursions will be corrected.

The battery or VR tube maintains the cathode of the control tube at a constant voltage above ground, and thus provides a standard reference voltage to which voltage fluctuations at the output divider (R_1) are compared. The voltage at the grid of the control tube is the difference between the voltage at the output bleeder tap and the reference bias voltage provided by the VR tube.

This difference voltage sets the "target" voltage to which the supply regulates. By changing the output bleeder tap with a potentiometer at R_1, the regulated output voltage of the supply may be adjusted within certain limits.

Summarized briefly, the action of the electronic regulator of Fig. 2 is as follows: The position of the bleeder tap on R_1 determines the output voltage level to which the supply will regulate. If the voltage across the bleeder attempts to rise above that level, the bias on the control tube (V_2) becomes more positive, causing it to draw more current through its load resistor (R_2). The increased current through R_2 causes the grid of the regulation tube (V_1) to be driven more negative, with the result that the resistance of the regulator tube increases sufficiently to prevent the original attempted excursion of output voltage and return it to the regulated level. If the output voltage attempts to *decrease*, the sequence of events is exactly opposite. The action is practically instantaneous, so that excursions are corrected for while still very small.



R_1, R_5, R_6, see text.
R_2, 0.5 meg., 1 watt.
R_3, 12k. 5 watts.
R_4, 18k. 5 watts.
L_1, 8H. 100 ma.
V_1, 6A3, V_2, 6SJ7, V_3, VR150, V_4, 5U4G.
C_1, 0.25 μf. 600v.
C_2, 8 μf. 450v. electro.
T_1, 550–0–550v., 100 ma., 5v. 3a., and 6.3v. 1 a.
T_2, 6.3v. 1a.

PRACTICAL DESIGN CONSIDERATIONS

With a working knowledge of the functions of all component parts, the design of regulated power supply equipment is no more complicated than that of other electronic circuitry usually designed and constructed by the user.

As with any power supply design, the first step is to determine the designed output voltage and current requirements. This permits the selection of the proper power transformer, filter components, and pass tube. The supply section differs from standard design only in that considerably more voltage than the required output voltage must be provided since there is an appreciable minimum voltage drop across the regulator tube. Usually the unregulated section of the supply must furnish from 50 to 200 volts more than the desired regulated output.

For a sample design, let us suppose that a regulated output of about 300 volts at 75 milliamperes is required for a general utility supply. The practical circuit for such a supply is shown in Fig. 3. Knowing the current requirement, a suitable pass tube may be selected from Table I. Any triode or triode-connected pentode capable of passing the required current at a reasonable voltage drop may be employed. Tubes may readily be used in parallel where greater current is required or when greater plate dissipation is needed. Special types, such as the 6AS7 which was designed for pass tube applications, are also available. For our present design, a smaller tube such as the 2A3 or its 6.3 volt equivalent, the 6A3, will suffice.

The power transformer and filter choke must be *conservatively* rated for the full load current. Otherwise, the regulation of the supply will be poor. The required voltage rating for the transformer is determined by finding the sum of the voltage drops around the circuit for the condition of maximum output voltage and current. The drop across the pass tube is minimum for maximum output voltage and may be found by referring to the plate characteristic curves for the pass tube being used. For the 6A3 used in the present design, the minimum tube drop for the required load current is about 80 volts at zero bias. Actually, somewhat greater values should be designed for to provide a margin for low line voltage conditions. For the 6A3, a minimum drop of 140 volts is typical. Thus, the D.C. output of the supply section ahead of the regulator must be about 440 volts; 300 volts for the load and 140 minimum drop across the pass tube. Reference to the rectifier tube operating characteristics will indicate the R.M.S. voltage rating of the power transformer required to supply this voltage when a single section choke-input filter is used. With the 5U4-G employed in the present design, and allowing sufficient margin for voltage drop across the choke, low line voltage, etc., a transformer delivering 550 volts each side of centre-tap at 100 ma. is indicated. The choke should also be rated at 100 ma.

At this point, having selected the pass tube and determined the characteristics of the unregulated supply section, it is well to examine the pass tube operating conditions to determine if the allowable plate dissipation is being exceeded. The 6A3 is rated at 15 watts maximum dissipation. At full current and voltage from the supply, the drop across the pass tube estimated above was 140 volts. The plate dissipation under this condition is 140v. times .075 amps. or 10.5 watts. The low voltage limit to which the supply can safely be adjusted at full current may now be determined, since the voltage drop across the pass tube, and hence its plate dissipation, is maximum at the lowest regulated output voltage. The allowable

drop for 15 watts plate dissipation is now calculated as 15 watts, .075 amp. or 200 volts. With a total unregulated voltage of 440v. available, the minimum regulated output of the supply is thus 240 volts. By using a larger pass tube, or several in parallel, the range of regulated voltage adjustment can be appreciably extended.

The choice of a control tube is rather arbitrary. Almost any pentode having a sharp cut-off characteristic may be used. The type most frequently employed in electronically regulated supplies is the 6SJ7, which is chosen for its low cost, ready availability, and high gain. Miniature types having similar charactersistics may be used in applications where space is at a premium. The 6SJ7 will do nicely for the design under consideration.

TABLE I

TUBE TYPE	CURRENT (Ma.)
6AS7G	250
6A3	75
2A3	75
6B4G	75
6A5G	75
807 *	80
6L6 *	75
6V6 *	45
6F6 *	40
6Y6 *	60

* Screen connected to plate through 500 Ohm, 1 Watt resistor

Although batteries may be used for the source of control tube reference bias voltage, the gaseous voltage regulator tube is usually preferred. Tubes of the "VR" series give excellent life and stabilization in this application. The choice of VR type, VR75, 90, 105, or 150, depends on the unregulated voltage available and the portion of this which must be reserved for drop across the load-bias resistor (R_2) and the control tube. It is desirable to utilize the highest voltage VR tube possible under these conditions, since this subjects the grid of the control tube to a larger portion of output voltage fluctuations. A VR150 is sufficient for the design being discussed, since the bias developed across R_2 to reduce the output voltage to minimum is only about —30 volts, as indicated by the plate curves for the 6A3. The plate load resistor (R_2) is chosen to be about equal to the plate resistance of the control tube. Values between .47 and .68 megohm are typical for the 6SJ7.

The by-pass capacitor, C_1, is usually about .25 μf. It provides a path for 120 cycle ripple voltages and other high frequency fluctuations between the regulated output and the grid of the control tube.

The dropping resistors R_3 and R_4 are designed to provide 150 volts across the VR tube at the 8 ma. minimum current required for regulation and to provide a tap for control tube screen voltage. In computing the values of these resistors, the minimum unregulated supply output voltage must be used. Allowing for 10 per cent. drop in line voltage, this would be 396 volts in the present case. The required drop is then 396 minus 150 or 246 volts. At .008 ampere drain, the total resistance required (R_3 and R_4) is 246/.008 or 30,750 ohms. The portion of this resistance between the cathode

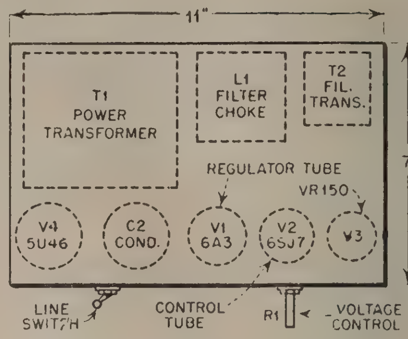
and screen of the control tube to furnish a screen voltage of 100 volts should be 100/.008 or 12,500 ohms. Thus the nearest standard values of 12,000 and 18,000 ohms will suffice for R_3 and R_4 respectively.

The total resistance value for the output bleeder is usually about .25 megohm, made up of a 50,000 wire-wound potentiometer for the voltage output adjustment and fixed carbon resistors (R_5 and R_6) above and below it to complete the total. The exact values of these for any particular regulated supply are most easily determined experimentally by substituting a .25 megohm potentiometer temporarily in place of R_1, R_5, and R_6. Then, with the supply operating, the settings of the potentiometer tap for the minimum and maximum output voltages allowable under full load conditions can be determined. The potentiometer is then disconnected and the resistance measured with an ohmmeter. The resistance between the slider position for low voltage output and the ground end of the "pot" is the value for R_5. Similarly, the resistance measured between the slider setting for high output voltage and the "hot" end of the potentiometer is the value of R_6. The correct value for R_1 is then R_5 plus R_6 subtracted from .25 megohm.

CONSTRUCTION

Standard power supply wiring practices apply to all portions of the regulated supply except the control tube section. Since this tube is acting as a high gain D.C. amplifier, it is very susceptible to hum pick-up which will appear as ripple in the output voltage. To minimize this, all leads associated with the control tube, and especially the grid lead from R_1, must be as short as possible. The best practice is to mount the voltage control potentiometer adjacent to the control tube socket at a location as far as possible from the power transformer, filter chokes, filament transformers, and other components which produce hum fields.

A chassis lay-out which is suitable for the design discussed above is shown in Fig. 4. All parts are mounted on a 7 x 11 x 2 inch metal chassis. Well-shielded components should be used and all A.C. leads must be twisted in pairs to reduce hum radiation. A separate filament winding is required for the regulator tube since the filament of this tube is operated at the full supply output voltage above ground. When the special 6AS7G pass

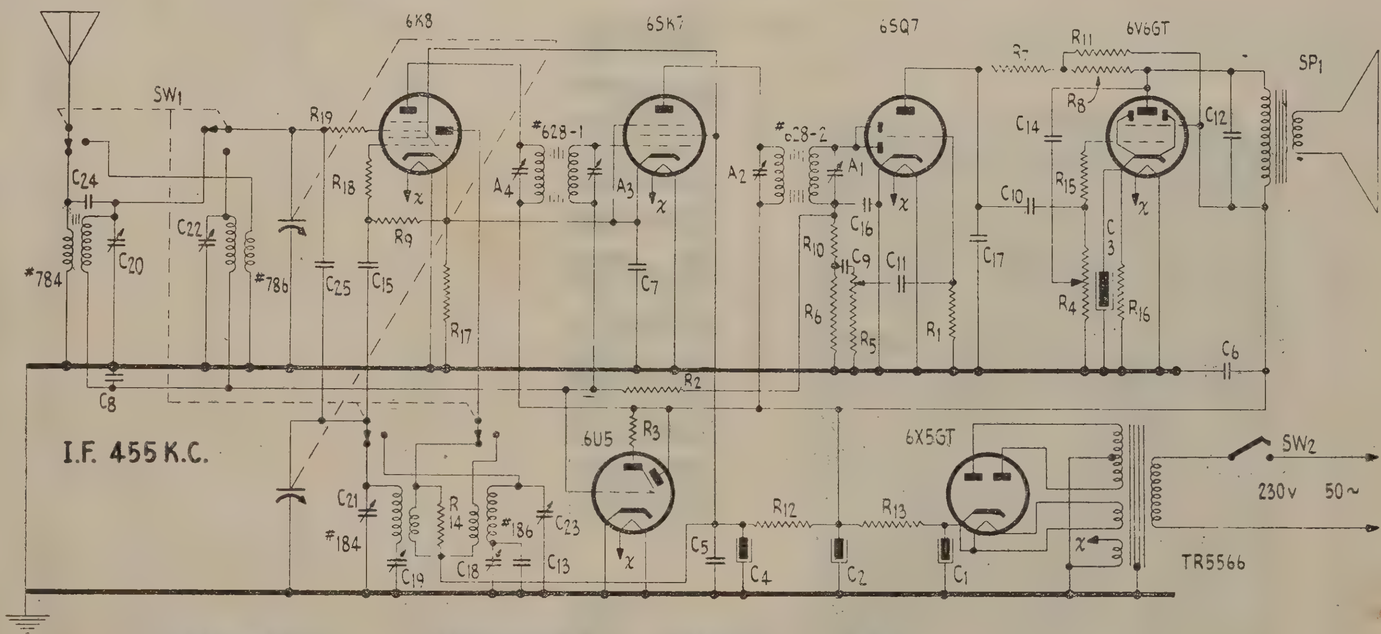


SUGGESTED PARTS LAYOUT
FOR REGULATED SUPPLY
FIG. 4

tube is used, this precaution is not necessary because the heater-cathode insulation in this tube is sufficient to withstand 300 volts.

The completed supply should be checked for satisfactory regulation by varying the load current from the full design rating to zero. Under these conditions, the change in output voltage should be negligible. Ripple content can be checked qualitatively with earphones coupled through a suitable condenser, although an oscilloscope is very much preferable.

FOR THE SERVICEMAN—Gulbransen Model 628



SCHEMATIC DIAGRAM MODEL 628

VOLTAGE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
Conv.	6K8	O	O	240	95	--5	90	6.3 a.c.	3.5
I.F.	6SK7	O	O	3.5	O	3.5	90	6.3 a.c.	240
Det-AF.	6SQ7	O	O	O	O	O	120	6.3 a.c.	O
Output	6V6GT	O	O	225	240	O	O	6.3 a.c.	13
Rect.	6X5GT	O	340	320 a.c.	O	320 a.c.	O	340	340
Eye	6U5	O	20	O	240	O	6.3 a.c.		

RESISTANCE READINGS

Use	Tube	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8
Conv.	6A8	O	O	.5 meg	.515 meg	50 K	.515 meg	O	150 ohm
I.F.	6SK7	O	O	150 ohm	1.55 meg	150 ohm	.515 meg	O	.5 meg
Det-AF.	6SQ7	O	10 meg	O	.55 meg	.55 meg	1 meg	O	O
Output	6V6GT	O	O	.5 meg	.5 meg	.505 meg	.5 meg	O	300 ohm
Rect.	6X5GT	O	.5 meg	275 ohm	Inf	270 ohm	Inf.	.5 meg	.5 meg
Eye	6U5	O	1.5 meg	1.5 meg	.5 meg	O	O		

1. D.C. voltage measurements are at 2,000 ohm per volt—A.C. voltage measurements at 1,000 ohm per volt.
2. Socket connections are shown as bottom views.
3. Measured values are from socket pin to common negative.
4. Nominal Tolerance on component value make possible a variation of ± 10% in voltage and resistance readings.
5. Volume control at maximum, no signal applied for voltage measurements.
6. Resistance readings in B+ circuits may vary widely according to condition of filter capacitors.

TECHNICAL INFORMATION

COVERING

DUAL WAVE RECEIVER TYPE 628

COLLIER & BEALE Ltd., WELLINGTON.

TYPE SET—A.C. Superhetrodyne.

TUBES (Six)—6K8 Converter, 6SK7 I.F. Amp., 6SQ7 Det.-A.F., 6V6GT Power Output, 6X5GT Rectifier, 6U5 Magic Eye.

POWER SUPPLY—230v. A.C. Rating 50 watts.

TUNING RANGE—Broadcast,530-1620 K.C.; Short Wave, 625-19.2 M.C.

ALIGNMENT INSTRUCTIONS

Set volume control at maximum and keep output from signal generator no higher than necessary to obtain output readings. Position of scale can be adjusted in cabinet by loosening grub screw on top drive drum and revolving scale to desired position before retightening grub screw.

Dummy Antenna	Signal Generator Coupling	Sig. Gen. Frequency	Band Switch Position	Radio Dial Setting	Output Meter	Adjust	Remarks
.1mfd	High side to grid of 6K8	455 Kc.	BC	High freq. end	Across voice coil	A1, A2, A3, A4.	Adjust for maximum output
R.M.A.	High side to ant.	1400 Kc.	BC	1400 Kc.	"	C21	
Standard	terminal	1400 Kc.	BC	1400 Kc.	"	C20	" "
"	" "	600 Kc.	BC	Rock Variable	"	C19	" " Recheck C21 at 1400 Kc. If C21 is changed recheck C19.
"	" "	18 Mc.	SW	18 Mc.	"	C23	Adjust for maximum
"	" "	18 Mc.	SW	18 Mc.	"	C22	output

CAPACITORS

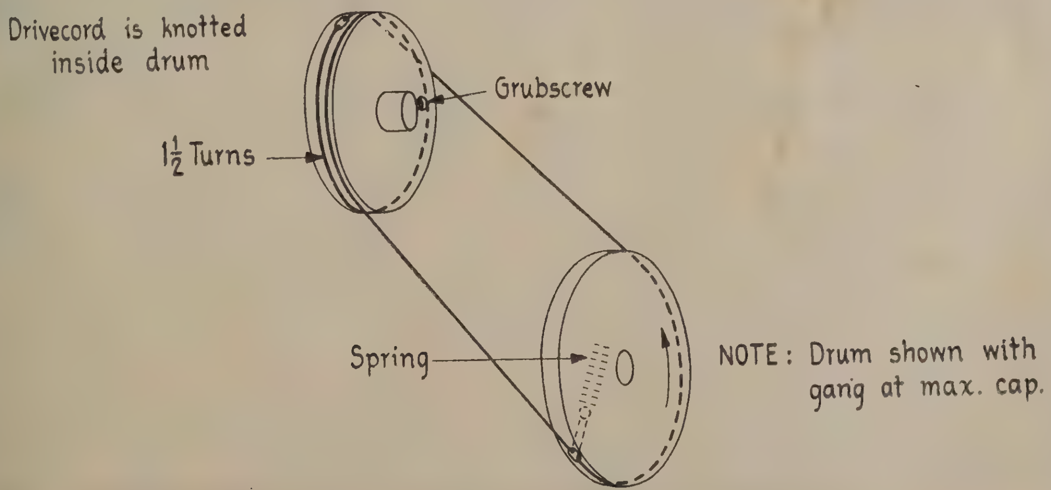
Ref. No.	Cap.	Volts
C1	40mfd	450
C2	40mfd	450
C3	25mfd	25
C4	8mfd	450
C5-7	.1mfd	600
C8	.05mfd	400
C9-11	.01mfd	600
C12	.001mfd	mica
C13	.001mfd	mica
C14	.0005mfd	mica
C15-17	.0001mfd	mica
C18	1000mmf	padder
C19	600mmf	padder
C20-23	3-30mmf	trimmer
C24	5mmf	ceramic
C25	1mmf	gimmick

MISCELLANEOUS

Ref. No.	Res., Pri.	Res., Sec.	
784	20 ohm	2.7 ohm	
184	1.8 ohm	2.3 ohm	
786	.4 ohm	.03 ohm	
186	.4 ohm	.03 ohm	
628-1	6.75 ohm	6.75 ohm	
628-2	6.75 ohm	6.75 ohm	
	Volts	**Volts**	**Volts**
TR5566	230	350 aside	2 x 6.3
	Type	**Transformer**	
SP1	8" P.M.	5000 ohm	
SW1	Bandswitch SW5283-$\frac{5}{16}$		
SW2	S.P.S.T. switch attached to R4		

RESISTORS

Ref. No.	Res.	Watts
R1	10 meg	½ watt
R2-3	1 meg	½ watt
R4-5	.5 meg	Pot.
R6	.47 meg	¼ watt
R7	.27 meg.	½ watt
R8	.1 meg	½ watt
R9	.051 meg	½ watt
R10	.033 meg	½ watt
R11	15,000 ohm	½ watt
R12	15,000 ohm	1 watt
R13	1,500 ohm	5 watt
R14	1,000 ohm	½ watt
R15	500 ohm	½ watt
R16	300 ohm	1 wat
R17	150 ohm	½ watt
R18	75 ohm	½ watt
R19	47 ohm	½ watt



The PHILIPS Experimenter

An Advertisement of Philips Electrical Industries of N.Z. Ltd.

No. 40: An Experimental Final Amplifier for Six and Two Metres

INTRODUCTION

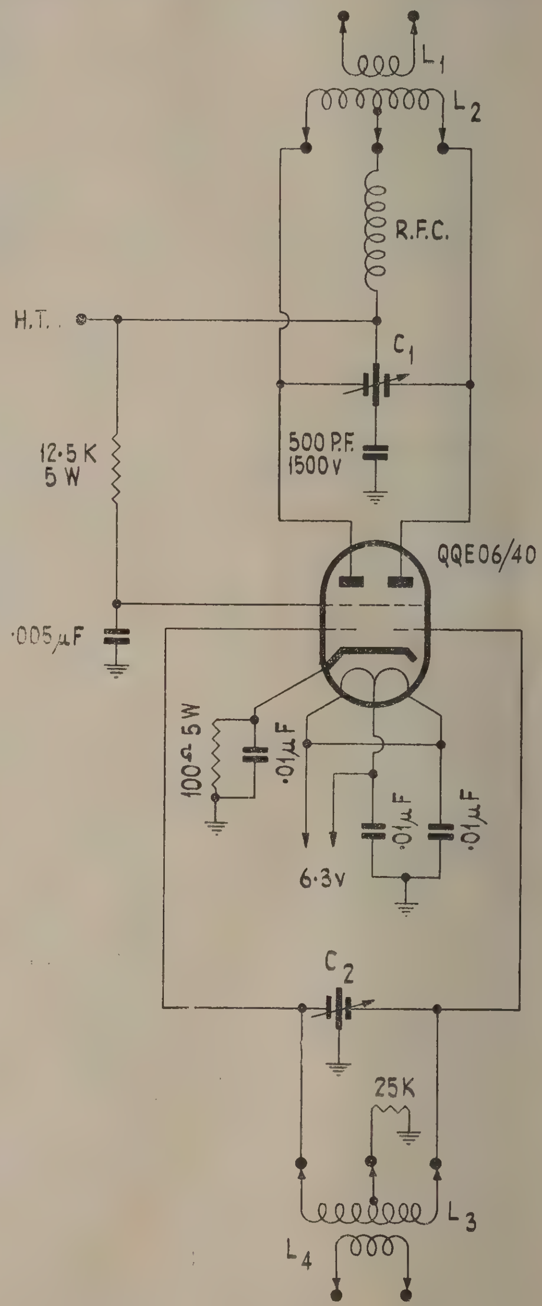
In Philips Experimenters, Nos. 34 to 36 inclusive there were described the design and construction of a low-powered exciter or transmitter for the 50–54 mc/sec. and the 144–148 mc/sec. bands. This provided several watts on both bands, sufficient for communication purposes under good conditions and over short distances; frequency stability was excellent, because of the incorporation of crystal control, and the efficiency was high, owing to the use of a combined output tank circuit and π-section output coupler for the QV04/7 modulated amplifier.

While this unit was excellent in its class, there remains a requirement for a transmitter with rather more output power, and it is with this idea in view that the medium-powered stage to be described below was designed. The valve used is the same one that was employed as the final amplifier of the Philips 100-watt transmitter, namely the QQE06/40. This was chosen for a number of reasons. In the first place, it is an excellent performer at very high frequencies, for which it is particularly suited on account of its double-tetrode construction, wtih a common cathode sleeve for the two units. In particular, the physical dimensions of this valve make it very easy to apply the open-wire line type of tuned circuit for the 2-metre band's plate tank, while retaining the quite efficient conventional coil for six. In this way, it has been possible to obtain good efficiency of the overall circuit on both bands, while at the same time providing the convenience of plug-in coils for both grid and plate circuits. By using a shortened plate line for the 2-metre band, it has also been possible to dispense with tuning by means of a shorting bar, and use the same midget split-stator condenser for tuning the plate circuit on both bands.

In order to reduce to a minimum the number of operations required when changing bands, use has been made of an ingenious arrangement whereby each output tank circuit has its own output coupling link, and each is individually adjusted. Thus, when changing bands, there is no necessity to adjust the output coupling, which can be set for each band during the initial adjustment procedure.

USE OF THE AMPLIFIER

Since grid and plate circuits of the amplifier can be separately plugged in, and because of the fact that the exciter is arranged so that it can give output on the band which represents the third sub-harmonic of the 144 mc/sec. band, it is possible to use the QQE06/40 stage in two ways for operation on the 2-metre band. Excitation can be applied at the fundamental, making the stage a straight push-pull amplifier, or, with the plate circuit tuned to two metres, and the six-metre grid coil inserted, excitation can be applied at frequencies between 48 and 49.33 mc/sec. In this case, the QQE06/40 acts as a push-pull tripler. This can be done because the exciter's output tank circuit, while designed to cover the six-metre band, will quite readily tune to the lower frequency mentioned, so that with a crystal suitable for the two-metre band inserted, the complete line-up is as follows. The oscillator gives output at frequencies



between 24.0 and 24.66 mc/sec., which is doubled in the second half of the ECC91 to 48–48.33 mc/sec. The band switch is set to the six-metre position, not the two-metre one, so that the QV04/7 acts as a straight amplifier on the last-mentioned band, exciting the QQE06/40 as a tripler.

Alternatively, of course, the exciter can be tuned up on the two-metre band, in the ordinary way, exciting the QQE06/40 as a straight amplifier on this band.

The ratings of the QQE06/40, as given in the data sheets, show that it can be worked with up to 600 volts on its plate, under C.W. conditions, and with 450 volts, under plate and screen modulation. In the latter case, a carrier output of 45 watts can be had, and this is a sizeable amount of power on the V.H.F. bands—particularly when it is remembered that many essential services using V.H.F. operated their fixed transmitters with a power output of about 20 watts only. The point is that there is no necessity to use the full plate and screen voltages on the QQE06/40 if it is desired to economize on the plate power supply, the amount of grid drive, or both. The valve is an excellent performer at low voltages. Indeed, when the laboratory model of the amplifier we are describing was first tested, it was run with only 250 volts on its plate, and with the same screen dropping resistor as is required when the plate voltage is 450. Under these conditions, the screen voltage must have been much lower than the statutory 250, and yet it was possible to get a good 12 watts output on 144 mc/sec. with only 2 ma. of grid current! The moral of this story is that the amplifier can be very useful indeed at plate inputs very much lower than the maximum recommended operating conditions specify.

There are also a number of possible ways in which the amplifier could be used; if working as a straight amplifier, it can be plate-and-screen modulated in the ordinary way, but there are other possibilities. Since the exciter is provided with its own modulator, and can therefore supply a 100 per cent. modulated signal, it should be possible to alter the operating conditions to make the QQE06/40 stage a Class B linear stage. In this case the drive needed will be rather greater, and it will be necessary to use fixed bias rather than grid leak, as shown. And, of course, the power output will be smaller. As far as modulation is concerned, there is yet another possibility that could be a useful idea for those experimentally inclined. It is to use partial modulation of the driver, and partial modulation of the plate and screen of the final. This scheme is used on the SCR522, a well-known wartime V.H.F. equipment, and enables the modulating power to be somewhat lower than would be needed for full plate modulation. It also allows the drive to the final under static (*i.e.,* no modulation) conditions to be rather less than is needed for full plate modulation, and consequently appears to have possibilities for use in amateur equipment, especially at V.H.F., where sufficient drive for high-powered stages is not so easy to come by.

THE "R. & E." AMATEUR TELEVISION PROJECT

PART III

THE TIME-BASE CIRCUITS IN DETAIL

The two time-bases are very similar to the simple saw-tooth generators used in oscilloscopes, and will no doubt be familiar to many readers. They both employ gas triodes, and except for one or two simple modifications, have circuits identical with the one used in most 'scope time-bases of this nature. The frame circuit is the simpler of the two, and so will be described first. The tubes in the top row of the complete circuit diagram are, from left to right, V_1, V_2, and V_3 of the block diagram. The left-hand 6SN7 is the multivibrator, working on 50 c/sec., the EN31 is the saw-tooth generator proper, while the remaining 6SN7 is the paraphase amplifier which amplifies the saw-tooth and feeds it to the Y plates of the C.R.T. It would perhaps be best to describe the gas-tube circuit first, since this is the fundamental part of the arrangement.

The EN31 is provided with a plate series resistor of 500k., and a condenser of 1 μf. from plate to earth. The cathode is biased positively by means of a voltage divider network from H.T., consisting of a 75k. and a 10k. resistor in series. This, with an H.T. supply of 300 volts, makes the cathode approximately 35 volts positive with respect to earth, and since the control grid is at earth potential, owing to its 25k. leak resistor being connected directly to earth, this is equivalent to a negative grid bias of the same amount, namely 35 volts. In the usual gas-tube saw-tooth oscillator, the negative grid bias is usually much smaller than this, so that the same circuit is able to act as a self-running saw-tooth oscillator. In this case the mechanism is as follows: When the H.T. is first switched on, the plate condenser commences to charge through the 500k. resistor, and since the plate of the valve is connected directly to the condenser, the plate voltage rises at the same rate as the condenser charges. When the striking voltage of the valve is reached, it suddenly ionizes and starts to conduct, rapidly discarging the condenser and giving the fly-back part of the saw-tooth. But in the present circuit, the negative grid bias is so high that even when the condenser is fully charged to the 300 volts of the H.T. line, the striking voltage of the gas tube is not reached, and the flyback does not occur. The circuit will thus not oscillate on its own account, and must be *forced* to start conducting, to produce the flyback. It is here that the triggering oscillator comes in. The multivibrator oscillates at approximately 50 c/sec., and produces a square-wave at this frequency. This square-wave is fed to the grid of the gas tube through a short-time-constant differentiating circuit, consisting of the 0.02 μf. coupling condenser and the 25k. grid leak. This transforms the square-wave output of the multivibrator into a series of alternate positive and negative pulses, which are applied to the grid of the EN31. Now while the plate condenser of the gas tube is charging up, the grid of this tube receives a sharp positive pulse of about 50 volts amplitude, so that as soon as this comes along, the gas tube is forcibly brought to its critical voltage, and it strikes, discharging the condenser, and causing the flyback. As soon as the condenser is discharged, the plate voltage on the gas tube is so low that it goes out, and is unable to conduct again until triggered once more by the next positive pulse on the grid. But in the meantime, the condenser has been charging again, giving the forward stroke of the saw-tooth. Thus, it can be seen that by the simple modifications of biasing the gas tube so heavily that it will not perform free oscillations, and then making it conduct only at times governed by the positive pulses sent to its grid, we have transformed the circuit into a triggered time-base, which can run at one frequency, and one frequency only—namely that of the train of pulses provided by the multivibrator. Also, should the multivibrator stop oscillating for any reason, there will be no time-base output from the gas tube. The frequency of the saw-tooth is rigidly controlled,

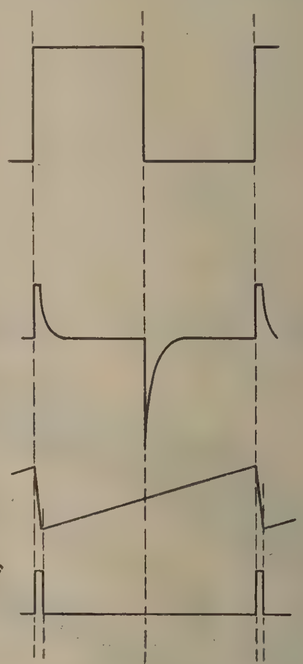


Fig. 4.—Waveforms to be found in the frame time-base circuit.

therefore, and is not affected by the value of the plate condenser, or that of the series plate resistor. All these do is to control the amplitude and linearity of the saw-tooth. By increasing these components to high values, as has been done here, it is ensured that the condenser charges to only a small fraction of the available 300 volts before the tube is forced to conduct, and as a result, only the first, almost linear portion of the condenser's charging curve is used. Since there is an amplifier following the saw-tooth generator, there is no necessity for a saw-tooth of large amplitude, so that we can obtain the advantage of improved linearity, at the expense of small amplitude.

There are one or two points about the circuit that have not yet been mentioned, and which readers may wish to have explained. For instance, why are the grid leaks of the multivibrator returned to H.T. positive instead of to earth, as is more usual, and what is the purpose

of the 15k. grid stopper in the EN31 circuit?

It is found that if the grid leaks of a multivibrator are returned to H.T.+ instead of to ground, the frequency stability is much improved. This is because the times when the multivibrator flips from one condition to the other, are much more positively controlled if there is a slight positive bias on the valves. It might appear at first that the grids are being worked with a positive bias equal in value to the H.T. voltage, but such is not the case. The reason is that when the valves draw grid current, as they must do, through the 1 meg. grid leaks, a large negative grid voltage is built up which almost completely counteracts the positive voltage. As a result, the grids cannot go more than a fraction of a volt positive even during the portion of the oscillation cycle when their own valve is conducting, and, of course, during the other half cycle the tube is cut off in any case.

A glance at Fig. 4, which shows the wave-forms which occur in the circuit, shows that as well as the positive pulses, at multivibrator frequency, fed to the EN31 grid, there are also negative pulses fed to the grid. These occur almost exactly half-way through the time-base stroke, when the gas tube is cut off. As a result, they have no effect at all on the operation of the circuit, and can be ignored. Since, also, the positive pulses provided at the grid are of greater amplitude than the permanent negative bias on the cathode, these pulses must drive the gas tube's grid positive, and must, therefore, cause grid current to flow. The purpose of the 15k. grid stopper is therefore to limit this grid current to a safe value that will not damage the tube. Again because of the grid current, the appearance of the pulses at the grid is as shown on Fig. 4. If the EN31 were removed from its socket, the positive and negative pulses would be found to be of the same size, so that the reason for the postive ones appearing shorter in amplitude in the actual working circuit is that the remaining portions are removed when grid current flows in the gas tube.

It will be seen that in series with the cathode lead of the gas tube there is a 250-ohm resistor. This it put there to enable a pulse to be generated, which can be used for blacking out the flyback of the vertical time-base. The EN31 conducts only during the flyback, and so at this time there is a positive potential developed across the 250-ohm resistor. This potential lasts only as long as the tube is conducting, and so forms the short positive pulse illustrated in Fig 4. This pulse is amplified by the first section of the ECC35, and fed to the grid of the second section, which acts as a cathode follower output valve for the pulse. In the process the pulse is, of course, turned into a negative one, because of the phase-reversing action of the amplifier valve, it can then be fed to the grid of the cathode ray tube, causing the trace to disappear for the duration of the pulse, and thus for the duration of the flyback, which no longer appears.

The second 6SN7 is a straightforward paraphase amplifier which raises the frame saw-tooth output to a high enough voltage for swinging the deflection plates,

and at the same time provides a push-pull pair of deflection voltages so that the plates can be fed in a balanced manner. There is, unfortunately, a slight error on this part of the diagram. The left-hand half of the valve feeds the Y_1 deflecting plate, and at the same time supplies input voltage for the grid of the right-hand half. The grid of the latter half is connected to a voltage divider shown as being made up of two 1 meg. resistors in series. The error is that the lower of these resistors should have been shown as a potentiometer, with the grid of the valve attached to the moving arm. This makes a balancing control which enables the output of both halves to be made equal, and once set, this control can either be replaced with two resistors of the correct value, or else left in position as a pre-set adjustment. It would also be advisable to make the 1 meg. grid resistor of the left-hand half of the 6SN7 a potentiometer, to act as an output control.

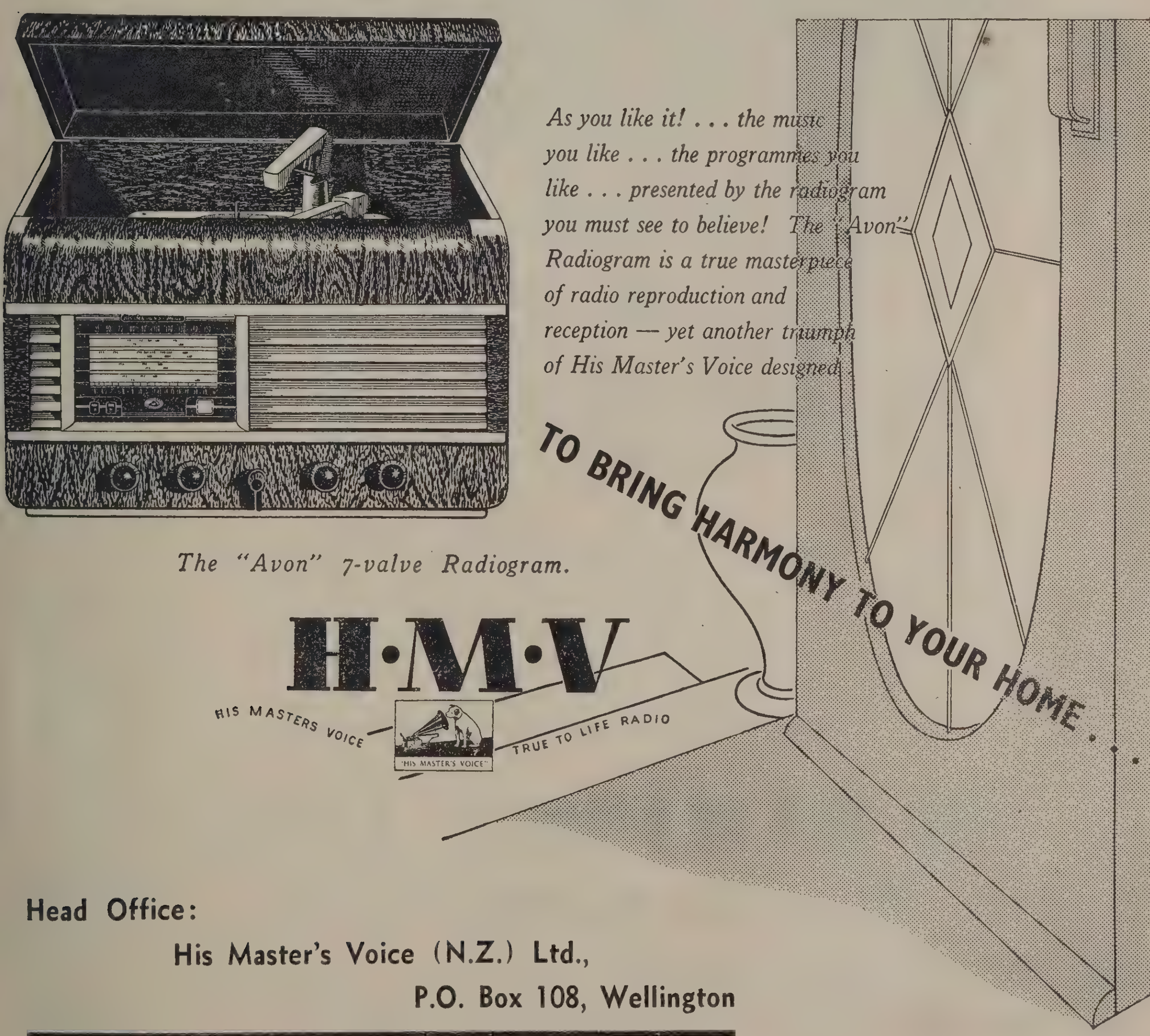
The circuit for the line time-base is exactly similar in principle to that of the frame circuit, but differs in detail owing to the necessity for generating a saw-tooth at a fairly high frequency. For our 300-line picture, the line frequency will have to be 300 times the frame frequency, which works out to 15,000 c/sec. Now, a saw-tooth of any frequency cannot be amplified without distortion unless the amplifier concerned has a response up to at least ten times the fundamental frequency of the saw-tooth. In the case of the frame saw-tooth, this does not present any difficulty, because ten times 50 c/sec. is only 500 c/sec., and ordinary resistance-coupled amplifiers will do much better than this without the slightest precautions to preserve high-frequency response. For the line time-base, however, the situation is rather different. An ordinary resistance-coupled triode stage has usually started to show distinct signs of falling off even below 15,000 c/sec., so that such an amplifier would be quite useless for amplifying a saw-tooth of this frequency. It is, therefore, necessary to use pentodes for amplification, and in order that the response shall be reasonably flat up to at least 150 k/sec., it will be necessary to apply semi-wide-band techniques. In our case, this amounts to (a) using a pair of high-Gm pentodes in the paraphase amplifier stage, rather than triodes, and for this we have chosen the ubiquitous 6AC7, and (b) limiting the plate load resistors to a low value so that the frequency response will be wide enough. A different type of paraphase amplifier is used, too, in which the phase inverting tube is excited from the unbalanced signal voltage to be found across a common cathode resistor.

The other main point of difference is that we no longer use a multivibrator as the controlling oscillator for the line gas tube. The reason for this is that to get a really good sharp square-wave from a multivibrator at 15,000 c/sec. would itself necessitate the use of two pentodes, also with low load resistors, so that in the interests of economy, we have used a single 6AC7, not as a multivibrator, but in an ordinary resistance-capacity oscillator circuit. Normally such a circuit is used to generate a sine-wave, but here, it is allowed to oscillate quite hard, with the result that it produces a wave-form which, though not a good square wave, is sufficiently squared off to enable it to produce triggering pulses after having been passed through a differentiating circuit similar to the one following the multivibrator in the frame circuit. The 400 $\mu\mu$f. padder in the oscillator circuit gives some degree of control over the line oscillator frequency, and will be found useful when it comes to operating the whole set-up.

In the line circuit there is a 6H6 which has no counterpart in the frame circuit. Both diode plates are earthed, and one cathode is connected at each end of the 15k. grid stopper for the EN31. It was found that the negative pulses given by the line oscillator after differentiating, were of much greater amplitude than the positive ones. It will be remembered that the negative pulses are merely a by-product, and serve no useful purpose. In the frame circuit, they do no harm either, but in the line circuit, they do have an effect on the charging current of the time-base condenser. The effect is thought to be purely an electrostatic one, due to the small capacity between the plate and grid of the gas tube, and to the large amplitude of the negative pulse. In any event, by connecting the 6H6 as shown, the negative pulse is removed by the conduction of the diodes. These have no effect on the positive pulses, since they cannot conduct when the cathodes are more positive than the plates.

Between the saw-tooth generator and the grid of the first 6AC7 amplifier is a fixed voltage divider, rather than a potentiometer. The reason is that the 6AC7 will not take the whole output of the saw-tooth generator without overloading. At the same time, we want as much voltage output as possible from them, so that the input voltage can be fixed just before the point where they start to overload. Then, in adjusting the shape of the picture, the frame time-base only is controlled as to output voltage. Across the 2 meg. upper portion of the input voltage divider, is a very small variable condenser of 5 $\mu\mu$f. maximum capacity. The purpose of this is to reduce the high-frequency loss sustained because of the high impedance of the grid circuit. In practice it is adjusted until the line time-base, as seen from the output of the amplifier stage, is as linear as possible.

(Continued on Page 48.)



The "R. and E." Senior Communications Receiver

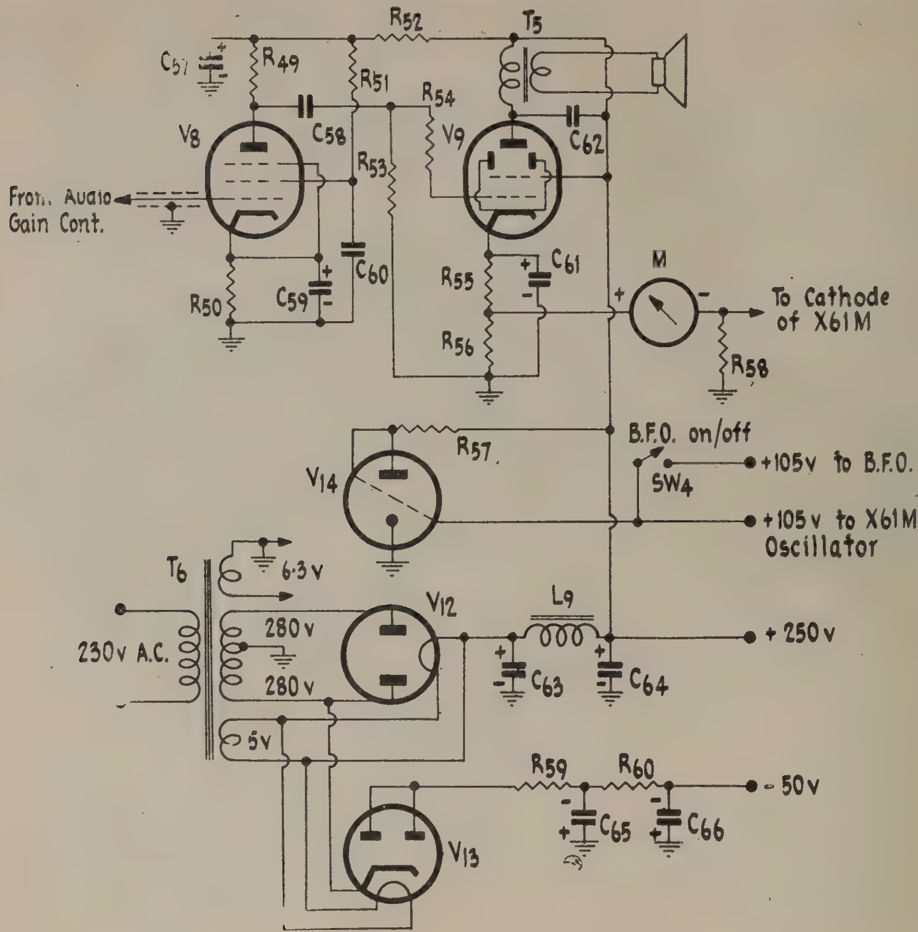
PART V

POWER SUPPLY AND AUDIO CIRCUITS

These were omitted from the main circuit diagram merely for ease of drawing, and so as not to complicate an already complex diagram still further. They are very straight-forward, however, and require little explanation. The output of the main circuit diagram is from the second detectors via the 455/100 switch, and is taken directly to the grid of the 6SJ7 voltage amplifier. This feeds the 6V6 output stage, which is also conventional except for its connection with the signal-strength meter, M. This latter feature is optional, and necessitates a very slight modification to the main circuit if it is to be incorporated. The cathode of the X61M, which is V_4 on the main circuit, is shown earthed, since cathode bias is not used, and if the S-meter is to be added it is necessary to lift the cathode from earth, and insert the resistor shown as R_{58} on the power supply diagram. This is best installed right at the X61M socket, and a lead taken off to the meter. It has only a negligible effect on the performance of the mixer valve, since it is so small in value, and again because of this fact, no attempt has been made to bypass it, since to do so effectively would necessitate a large mica condenser which would be a difficult part to come by. Tests showed that there was no necessity for R_{58} to be bypassed, and that the installation of the S-meter circuit had no noticeable effect on the performance of the set. The S-meter functions as follows:

The positive terminal of the meter is connected to the voltage divider, R_{55}, R_{56}, which comprises the cathode resistor of the 6V6. It is thus placed very slightly positive with respect to earth. When no signal is present, the X61M draws maximum current, the R_{58} is chosen so that under these conditions, the positive potential developed across it is just equal to the positive potential developed by the output tube's plate current flowing through R_{86}. There is thus no voltage across the meter, which reads zero. When a signal is present, A.V.C. voltage is applied to the grid of the X61M, whose plate current is reduced, causing a drop in the voltage across R_{58}. The negative terminal of the meter thus moves in a negative direction with respect to the potential of the positive terminal, and the meter reads upwards.

The 6V6 plate current is constant at all times, so that the potential of the meter's positive terminal does not change, however great the signal and thus the A.V.C. voltage. The resistors in the meter circuit are so proportioned that however great the A.V.C. voltage applied to the X61M, the meter will not read more than full-scale. It might be asked why the fixed positive voltage for the positive meter terminal is not obtained simply by a bleeder from H.T.+. If this were done, the meter would be deflected very strongly backwards dur-



R_{49}, R_{58}, 100k.
R_{50}, 600 ohms.
R_{51}, 250k.
R_{52}, 50k.
R_{53}, 500k.
R_{54}, 10k.
R_{55}, 250 ohms.
R_{56}, 25 ohms.
R_{57}, 6k.
R_{59}, 75k.
R_{60}, 50k.

C_{57}, C_{65}, 8 μf. 450v. electro.
C_{58}, 0.03 μf.
C_{59}, C_{61}, 25 μf. 25v. electro.
C_{62}, 0.005 μf.
C_{63}, C_{64}, C_{66}, 16 μf. 450v. electro.
V_8, 6SJ7.
V_9, 6V6.
V_{12}, 5Y3GT.
V_{13}, 6X5GT
V_{14}, VR105.
M, 0–500 μamps, D.C. Res. 500 ohms.

ing the set's warming-up period, because the rectifier will heat up more quickly than the X61M, causing the negative meter terminal to be at earth potential until the latter tube does warm up. But since the positive terminal is fed from the cathode circuit of the 6V6, which takes approximately the same time to heat as the other valves, the positive voltages fed to both meter terminals appear at approximately the same time, so that the meter is not violently deflected in either direction while the set is warming up.

The only thing that may require a little comment in the power supply circuit is the bias rectifier, V_{13}. This is a 6X5-GT, with its heater supplied from the 5v. filament winding for the main rectifier. Although the ratings of the 6X5 would not be exceeded if its heater were fed from the main 6.3v. winding, this connection minimizes the risk of a break-down in the 6X5's insulation between heater and cathode. For the minute current that the 6X5 has to supply, the 5 volts on its heater is quite adequate. It should be realized that the filter circuit at the ouput of the bias rectifier does not itself reduce the voltage at the output to 50 volts as it is shown on the circuit diagram. The smoothing resistors act as a voltage divider in conjunction with R_{47} and R_{48} on the main diagram, so that when the circuit is completed through these resistors, 50 volts appears at the junction of R_{60} and R_{47}. Should the power supply be built up as a separate unit, and not integral with the rest of the set, as here, it should be remembered that if the supply is switched on before being plugged into the set, the voltage at the terminal marked "—50v." will not be 50 volts

(Continued on Page 41.)

THE "RADIO AND ELECTRONICS" ABSTRACT SERVICE

AUDIO EQUIPMENT AND DESIGN

The reduction of hum is a problem which besets every designer sooner or later. Here is a careful analysis of various types of hum—plate impedance effect—grounding and balancing—choice of tubes—inside tubes—leakage, etc.

—*Radio and Television News* (U.S.A.), Nov., 1950, p. 55.

Those who require a high-quality sound system for the home should study this article which deals with the amplifier especially in relation to the cabinet, and should enable the enthusiast to assemble a high-quality system at low cost.

—*Ibid,* November, 1950, p. 59.

The Flewelling audio system described. This is an unconventional system which has engendered wide interest. A diagram of the two-stage amplifier is given which uses large coupling capacitators and a unique feedback circuit.

—*Audio Engineering* (U.S.A.), November, 1950, p| 18.

This article deals with architecture and acoustics from an historical and a modern point of view and compares the live-end-dead-end technique of recording with early acoustical practices, and offers a promising design for studios.

—*Ibid,* November, 1950, p. 21.

A misconception appears to be common with regard to the effect of the dynamic plate resistance of a tube driving a loudspeaker on the "damping" properties of the tube. Logical reasoning is applied to the problem of choosing between triodes and pentodes or tetrodes to obtain low output impedance and the resulting high damping factor.

—*Ibid,* November, 1950, p. 30.

ELECTRONIC DEVICES

Newly perfected methods of using radioactive isotopes as tracers in medical research have given rise to a need for high-speed counting equipment of greater versatility than previously available. Differential radiation counters determine position of accumulation of radio-active material which, when added to the blood stream, collects in the vicinity of tumorous tissue. This permits brain tumor recognition and location in a matter of minutes.

—*Electronics* (U.S.A.), November, 1950, p. 72.

Damping the noise of car tyres is of importance in industry, and a photoelectric commutator is used to release a microphone amplifier circuit when a sample tyre bears against a rotating drum. The resulting noise is studied with a resonant transient analyzer.

—*Ibid,* November, 1950, p. 84.

High-speed electronic commutators are inherently complicated, especially when designed to have a negligible switching interval. Here is described a system employing binary counters and a network of coincidence gating tubes to commutate 32 channels of information with essentially negligible switching time.

—*Ibid,* November, 1950, p. 94.

In the development of automatic machinery it is often desirable to have devices which have greater flexibility than cams for the delineation of shapes that forms the basis of manufacture. Such electronic devices may be referred to as memory devices, and may use magnetic tape in the place of the mechanical cam, the tape providing the means of moving the reproducing tool.

—*Ibid,* November 1950, p. 104.

MATERIALS AND SUBSIDIARY TECHNIQUES.

The theory of semi-conductors continues to exercise the minds of many experimenters, and the study of the movement of "holes" in the semi-conductors is here further developed. The article deals with: floating potential of point contact, low voltage conductance of point contacts—hole flow for a collector with large reverse voltage—and similar matters.

—*Bell System Technical Journal* (U.S.A.), October, 1950, p. 469.

MATHEMATICS

Much has been written on the subject of the conventional band-pass circuit, in which a signal is fed to a resonant circuit, and an output taken from a second resonant circuit coupled to the first. This paper is concerned with the arrangement of coupled circuitry in which input and output terminals are connected to the same tuned circuit and a coupled circuit absorbs power over a comparatively narrow band of frequencies.

—*Wireless Engineer* (England), August-Sept., 1950, p. 219.

The design of vacuum-tube amplifiers involves determining the maximum gain and/or bandwidth using the most economical tube arrangement. The equations involved in design of single-tuned amplifier circuits are incorporated in one large

nomograph to speed up design calculations, and show the overall effect of varying the parameters when seeking the most economical tube arrangement.

—*Electronics* (U.S.A.), November, 1950, p. 116.

MEASUREMENTS AND TEST GEAR

A micro-wave sweep generator described—a motor-driven plunger-cavity arrangement provides continuous klystron output from 2,600 to 3,400 mc/sec. at a sweep rate of 8 to 10 cps. It permits oscilloscope indication of match between wide-band travelling-wave tubes and transmission lines.

—*Ibid*, November, 1950, p. 101.

Measuring technique in telephone transmission work, particularly at carrier frequencies, calls for testing equipment of a specialized nature differing in some respects from that needed for radio-frequency measurements. In this article, an oscillator and a detector, designed for measurements on twelve circuit carrier systems, have been selected for description.

—*G.E.C. Telecommunications* (Eng.), No. 1, 1950, p. 25.

Many descriptions of the Geiger counter have been given from time to time. Here is a description of the Geiger tube and its working.

—*Radio and Hobbies* (Aust.), December, 1950, p. 23.

The paper describes a radio frequency millivoltmeter which is novel in principle and design. Developed for calibrating high output levels of a signal generator, it measures voltages of the order of 100 mV, the measuring element being a commercial thermocouple milliampermeter or vacuo-junction.

—*Proceedings of the I.E.E.* (Eng.), Part III, Sept. 1950, p. 334.

A circuit is given for a valve voltmeter circuit, which is especially designed for the students' laboratory, the requirements to be met being versatility in voltage and frequency ranges, and low cost.

—*Electronic Engineering* (Eng.), October, 1950, p. 420.

Phase differences may be measured accurately to 0.1 of a degree by the precision phasemeter described. Phase comparison is accomplished by a detector bridge consisting of four diodes arranged as a ring modulator. Phase difference is read directly from a decade voltage divider, which controls the amount of quadrature voltage added to a reference signal.

—*Electronics* (U.S.A.), October, 1950, p. 102.

MICROWAVE TECHNIQUES

The paper describes a microwave circuit designed for use with the 1553-416A close-spaced triode at 4000 mc. It presents data on tubes used as amplifiers and modulators and concludes with the results obtained in a multi-stage amplifier having 90 db gain.

—*The Bell System Technical Journal* (U.S.A.), October 1950, p. 531.

The paper describes a type of oscillator designed to provide a sweep to cover the communications band between 3700 and 4200 mc/sec. to facilitate the testing of components for radio relay repeaters. Basically the R.F. circuit consists of a tunable cavity for a grid-anode resonant circuit and a means for coupling the cavity to a wave-guide output.

—*Ibid*, October, 1950, p. 553.

A new V.H.F. multi-circuit radio telephone system described. The system has great use where short links across water are required or other physical features make land lines difficult. The paper deals with propagation problems—choice of frequency band, choice of sites and aerial tower heights—design requirements for a multi-circuit link, transmitting station, etc.

—*G.E.C. Telecommunications* (Eng.), Vol. 4, No. 2, 1949, p. 62.

PROPAGATION:

Microwave lenses; this is the sixth of a series of articles on this subject and deals with systems such as used in radar sets where it is desirable to produce a vertical radiation pattern to cover a given volume of sky or ground. There is also a comparison of lenses and mirrors, and some possible improvements in lens systems.

—*Electronic Engineering* (Eng.), October, 1950, p. 433.

RECEIVERS:

More selectivity at low cost—the constant increase in the number of amateur stations and their power leaves much to be desired in most home-made receivers in the matter of selectivity. The adaption of the I.F. transformers to give greater selectivity is described with notes of circuit alignment and performance.
—*QST* (U.S.A.), October, 1950, p. 26.

TELEVISION:

There is described a versatile phase-shift control for TV studio sync. generator. The device, which employs a selsyn system, affords rapid adjustment of the vertical sync. phase and with the aid of a vertical phase comparator permits vertical phase coincidence of sync. generators with a simple manual control.
—*Television Engineering* (U.S.A.), August, 1950, p. 8.

The streamlining of TV chassis; new design trends move to the consolidation of heretofore separated parts and components into pre-wired assemblies which in practice are found to reduce the number of separate parts by as much as 30 per cent.
—*Ibid*, p. 12.

The causes and remedies for TV interference—a report of nine sources of interference which include the second harmonic of FM stations, local oscillations of TV receivers, radio amateurs, and various types of medical and industrial equipment, and the methods being employed to overcome these types of interference.
—*Service* (U.S.A.), August, 1950, p. 20.

One of the most common criticisms of the picture quality of motion picture film produced over a TV chain is the washed out appearance of the white portions of the picture. A tone correction non-linear amplifier for correcting this defect is described with the circuitry.
—*Television Engineering* (U.S.A.), Sept. 1950, p. 12.

In any television broadcasting, considerable application is found for still subjects which may be photographed on to slides, and for these there is a use for the flying spot camera, which strangely enough is an almost complete return to the earliest principles used in television. In the system described the flying spot is the sharply focused spot on the phospor of a picture tube. The control and operation is described.
—*Ibid*, p. 16.

The text is given of a full report on the present status of colour television and the possibilitis of success from a practical point of view.
—*Proceedings of the I.R.E.* (U.S.A.), September, 1950, p. 980.

A high quality colour television system could be made by transmitting independently red, green, and blue images of equally high quality. The bandwidth required would be three times as great as for black and white, regardless of whether the images are transmitted in sequence or simultaneously. The basic theory and methods of mixing are reviewed.
—*Ibid*, p. 1003.

A lengthy review of some television pick-up tubes. The performance characteristics of some of these tubes are reviewed critically, and the review covers the emitron, super-emitron, and orthicon. In the light of the experience gained an attempt is made to draw up a specification of an ideal pick-up tube.
—*Proceedings of the I.E.E.* (Eng.), Part III, Nov. 1950, p. 377.

The frequency conversion stage of a TV receiver determines to a large extent the quality of the picture and the signal-to-noise ratio must be maintained. The paper deals with: circuit noise—thermal agitation m.f.s.—tube noise—converter circuits—oscillator stability and oscillator radiation.
—*T.V.E. Engineering* (U.S.A.), October 1950, p. 8.

In the three-colour systems which have been on trial, all have been of the additive type. It has been found that there are certain disadvantages, and in an attempt to secure more lighting a subtractive method has been probed. It has been found possible to employ this technique in a system which uses a light source independent of the picture tubes.
—*Ibid*, October, 1950, p. 12.

Special effects, both optical and electrical, play an important part in modern TV productions. It is frequently desired to combine two or more scenes into a single picture, and a method has been designed for blanking out any desired portion of the video signal and replacing it with a corresponding portion of another.
—*Ibid*, October, 1950, p. 14.

Electrically and magnetically controlled colour filters show promise for application in the production of coloured motion pictures. When polarized light is transmitted through a birefringent material a colour controlling phase shift may be introduced. Tuning the filter, or changing colour may be accomplished by rotating the axis of a variable phase shifter, electrically or magnetically.
—*Electronics* (U.S.A.), November, 1950, p. 112.

MISCELLANEOUS

The value of a telephone system is assessed on its ability to convey clear speech over distance, and the factors for this purpose are outlined—volume—articulation—correct reproduction of speech frequencies—qualities of microphones—transmitter and receiver. Some historical matter is introduced and notes on modern systems and production testing.
—*G.E.C. Telecommunications* (Eng.), Vol. 4, No. 2, p. 79.

A very compact high-voltage X-ray tube is described in which the accelerating voltage is developed in a resonant cavity excited by a high-power magnetron operating at 25 cm. The focal spot is very small, and as the output is pulsed the tube may be used as a stroboscope for the radiography of moving machinery.
—*Proceedings of the I.E.E.* (Eng.), Part III, Nov., 1950, p. 425.

This paper discusses the fundamental principles governing the radiation patterns of dielectric tubes, the influences of tube length, diameter, and wall thickness on the radiation pattern.
—*Proceedings of the I.E.E.* (Eng.), Part III, Sept. 1950, p. 311.

Measurements of atmospheric noise level have been made at a number of stations for periods of up to four years. Some of the results of these observations are presented in the form of median values for each month and each hour of the day. It is apparent that noise is not dependent upon storms and that the mechanism of noise generation is only partially understood.
—*Ibid*, p. 335.

The paper describes the nature of bioelectric potentials and their essential properties with particular emphasis on the types of amplifier needed to study various phases of bioelectric activity. Some of the problems and solutions to bioelectric instrumentation are discussed.
—*Ibid*, p. 1008.

A search for deleterious effects upon animals exposed to intense microwave radiation was made and definite damage to the eye and testicle was found. Ten centimeters proved to be the most dangerous wavelength. The work demonstrates the need for caution on the part of those who work with intense microwave sources.
—*Ibid*, p. 1028.

Modern electrobiology covers a vast field which ranges from the study of gross electrical phenomena such as are encountered in electric fishes, where differences of potential of several hundred volts can be recorded to that of minute electrical changes accompanying vital processes in single cells where only a few microvolts are involved. The study of these bioelectrical processes is discussed.
—*Proceedings of the I.E.E.*, Part I, September, 1950, p. 217.

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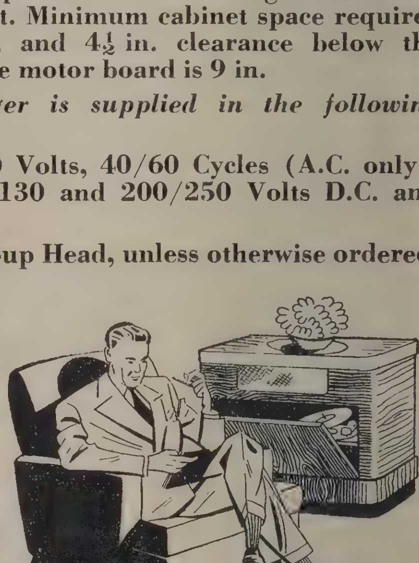

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PART II

This formula also gives a clue as to what must be done if a less sensitive meter is to be used. Actually, this will hardly be necessary because with the values used in the present design, the maximum allowable meter current is almost 3 ma., and a 1 ma. meter has been specified. This does mean, though, that if a 0–2 ma. meter were to be used, the readings would still be linear up to full scale, and slightly beyond. If, for example, it were desired to use a 0–5 ma. movement, the readings would be linear only up to 3 ma. unless the circuit were altered. From formula (2), it can be seen that the permissible meter current is made greater if V, the square-wave input voltage is increased, and if R the load resistor is decreased. However, it would not be possible to make any improvement just by altering the value of R, because this would also decrease V, the output voltage. So that if R were decreased, the H.T voltage would have to be increased so that there would not be a corresponding decrease in V. Another way of decreasing R without sensibly affecting V would be to place a cathode follower after the 6V6 squarer tube. The output impedance of the cathode follower would then be of the order of 500 ohms, while the output voltage would remain almost the same.

REMAINDER OF THE CIRCUIT

The remainder of the circuit consists of the power supply, and the switching arrangements which allow the meter to have a number of ranges, and to be correctly calibrated on each range. The H.T. supply is provided by a small power transformer of approximately 210v. a side, at 50 ma., rectified by a 6X5. A single section condenser-input filter is used, and the full H.T. voltage is applied to the cathode followers and the amplifier valve. The plate and screen of the 6V6, however, are supplied from a VR150 regulator tube. This is necessary because changes that may occur in the H.T. voltage applied to the 6V6 would alter the output voltage V, and thus change the meter reading. The series resistor of 3000 ohms in the VR150 circuit was found to be the right value with the transformer used in the laboratory version of the meter, but it does not follow that this will be correct for all power transformers. In practice, this resistor should be made a 10-watt wire-wound adjustable, and its value adjusted until the current through the VR tube is exactly 10ma. This can be measured without disturbing the circuit by measuring the voltage across the 200-ohm resistor below the VR tube. When the tube is passing 10 ma. the voltage should be just 2 volts. Incidentally, the purpose of this resistor, and its connection to the diode circuit is to eliminate the small meter reading that would occur due to contact potential in the meter diode.

It will be noted that a range switch has been provided which not only alters the condenser feeding the diode circuit, but also changes a series of pre-set shunts across the meter. These shunts are used in calibrating the scales, and their use will be described later.

We have not yet mentioned the purpose of the cathode followers before and after the 6J7 amplifier tube. Their purpose is to ensure that whatever the input voltage to the instrument, the reading will be the same after the necessary minimum input has been passed. They provide low-impedance sources to feed both the amplifier and the squarer valves, and their effect is to prevent the grid current, which flows in both valves if the input voltage is large, from altering the effective bias on them. If the grid current is able to build up a kind of grid-leak bias, as it will do if the grid circuit resistances are high, and the source feeding the valves has a high impedance, a disturbing effect occurs. It is that the square-wave no longer has top and bottom portions of equal duration. Then, there is only somewhat less than half the square-wave cycle during which the condenser can discharge, and if this is the case, the linearity will be upset. The effect shows up as a slight change of meter reading when the input frequency is kept constant, but the input voltage is increased. This is obviously to be avoided, since we would not then know which input voltage gives the correct meter reading. The use of the cathode followers reduces this effect to negligible proportions, and after an input of about 0.5 volts is reached, no further increase, up to almost any input voltage (some hundreds, in any case) has any effect on the meter reading.

CALIBRATING THE METER

Since the meter gives a linear indication of frequency, each range we may include starts from zero. Now the most accurate part of the meter's scale (and this applies to any meter at all) is from half-scale to full scale, and below half-scale the accuracy is less. It is thus desirable to have the ranges overlapping to a considerable extent, so that any frequency we may have to measure can be found at least from one-third scale to full scale. For this

reason, the ranges have a very generous overlap, and are as follows:— 0–100 c/sec., 0–300 c/sec., 0–1000 c/sec., 0–3000 c/sec., 0–10,000 c/sec., and 0–30,000 c/sec., giving six ranges in all. It has been found, though, that the meter is just as accurate up to a top frequency of about 100 kc/sec., so that if desired, extra ranges may be inserted to accommodate frequencies between 30 and 100 kc/sec.

It is quite an easy matter to work out the theoretically required values of the condensers, to give the desired full-scale readings. This can be done from Equation (1) if the output voltage of the 6V6 is accurately known; however, this is a difficult thing to measure accurately, so the best thing to do is to assume an output voltage, V, of 125 volts, which will not be far out. The required condenser values are then worked out, and the nominal values inserted in the circuit. Then when known frequencies are applied to the meter, corresponding to the desired full-scale readings, it is possible to see whether the meter reads below or above full scale. If slightly above, no change need be made in the condenser value for that range. The calibration is then completed simply by adjusting the meter shunt that is in circuit until exactly full scale is indicated. Then, since the meter indication is linear, no further calibration is needed for that range. Should the meter read less than full scale with the shunt in the maximum resistance setting, and the required frequency fed in, then small amounts of capacity are added to the condenser until the reading is increased to slightly above full scale. Then, the amount is brought into action,and the full scale reading set up. Of course, in order to calibrate the meter, a source of known frequencies will have to be available, so that it will be necessary to beg, borrow, or steal an accurately calibrated audio signal generator for the purpose.

MECHANICAL DESIGN

There is nothing at all critical about the lay-out of this instrument, and builders may please themselves just what form they build the unit up in, as long as ordinary and reasonable precautions are taken. It is, of course, necessary to keep the output of the 6V6 from being too close to the input of the instrument, since this could cause self-oscillation, but this is the only real precaution that need by taken. It is advisable to have a separate earth point for each stage, especially if it is expected to extend the readings up to 100 kc/sec., but if normal constructional practice for audio amplifiers is used, no trouble will occur, and the result will be found an easily built, and very useful instrument.

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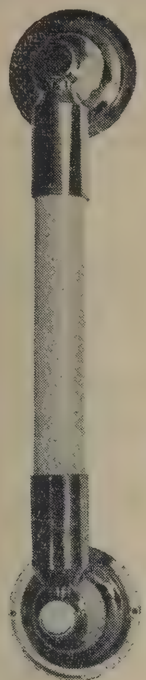

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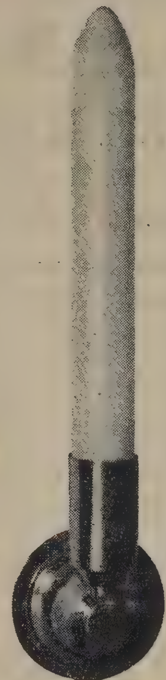

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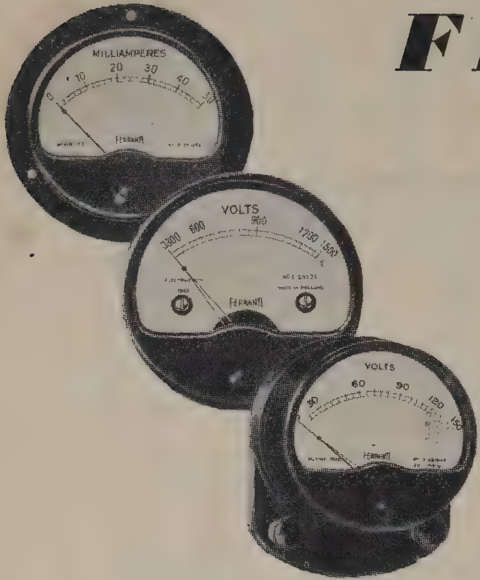

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at all, but more like 400, so that the insulation of the leads needs to take care of this fact. Of course, the power supply should not be switched on if the load is disconnected, but such things do happen, even in the best regulated circles.

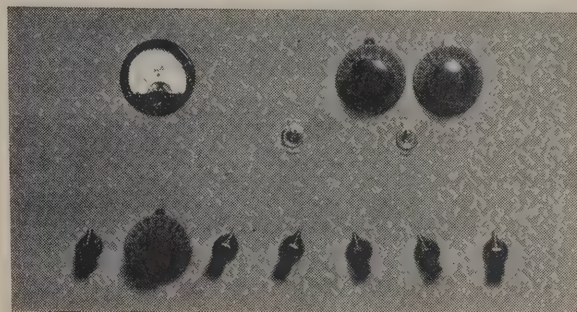
In order to aid the stability of the B.F.O. frequency, and also that of the oscillator in the 455 to 100 kc/sec. conversion, both these oscillators are supplied with regulated voltage from a VR105, V_{14} on the diagram. For the benefit of those who are not very familiar with these regulator tubes, we might mention that the dotted line across the tube symbol indicates a jumper connection inside the socket, which is wired in series with the output voltage when the tube is installed. The purpose of this is to make the oscillators inoperative should the regulator tube be unplugged from its socket, thereby ensuring that in this eventuality, the full H.T. voltage of 250 is not applied to the oscillators, and also that these parts of the set will not work unless the regulator tube is in its socket. The 105 volts is also useful for supplying the oscillator or oscillators in the tuner, since the extreme selectivity of the I.F. section makes it highly desirable for these oscillators to be supplied with a regulated voltage too.

SETTING UP THE COMPLETED RECEIVER

Enough has been said about the operation of the set in the earlier instalments to make detailed setting-up instructions almost superfluous. The 455 channel, in particular, is particularly easy to align. It is only necessary to ensure that the selectivity switch is in the "narrow" position, and align the circuits in the usual way. After this has been done, and it can be successfully accomplished using a signal generator and output meter, no further alignment is needed for the two "broad" positions, which automatically align themselves as long as the values in the switching circuit are as specified.

After the 455 circuits have been aligned, but not before, the 355 kc/sec. oscillator must be set to frequency, and the 100 kc/sec I.F. channel aligned. The best way to do this is to perform the latter operation first, feeding 100 kc/sec. into the grid of the X61M through a blocking condenser. The 100 kc/sec. selectivity control is then rotated to the "broad" position, which is the one where the moving arm is at the H.T. end of the potentiometer, and the two 100 kc/sec. I.F. transformers are aligned in the ordinary way. Then, with 455 kc/sec. fed into the input terminal, and the 455/100 switch set to "100," the 355 kc/sec. oscillator is tuned until the signal comes in "on the nose."

If all is well with the 100 kc/sec. amplifier, it should now be possible to rotate the selectivity control, without any detuning taking place, and without oscillation occurring. However, should R_{11} be too low in value, giving too much positive feedback, it is possible that the 100 kc/sec. channel will oscillate when the feedback is increased by rotating R_{12}. At this point, some careful work may be needed in adjusting the exact value of R_{11}. This is not made easier by the fact that currently available 10 megohm resistors are frequently nothing like their nominal value. Also, it is likely that differences in valves and resistor values will necessitate trial and error methods of settling the exact value of R_{11} in any case. The procedure to be followed is then like this: All resistors except R_{11} are installed, and the set is aligned as in the instructions above. Then, without R_{11} in circuit, all that will happen when R_{12} is rotated is that the progressively increasing negative feedback will decrease the gain. If the circuit has been properly built, operating R_{12} with R_{11} disconnected will not produce instability, and R_{12} will act simply as a smooth control of gain. The output meter is then connected to the set, and a 10 meg. resistor is inserted in the R_{11} position. Then, with R_{12} at the plate end of its travel, the gain, and therefore the output, should be approximately the same as when it is at the other end. If there is still a considerable drop in gain as R_{12} is rotated, it indicates that R_{11} is too large, and should be reduced. Various resistors are tried until one is found that gives neither oscillation, through too much positive feedback, nor considerable drop in gain, through not enough. As stated above, finding the right value may be a rather troublesome business, but once it is found, the circuit will be found to work exactly as set out in our original description of the functioning of the various circuits.



Front panel view of the completed receiver. The two dials at the right are those of the beat frequency oscillators, and the one in the bottom row is that of the 355 kc/sec. oscillator.

OPERATION

There are one or two points in which the operation of this set differs somewhat from the conventional communications receiver, which is hardly to be wondered at, considering the unconventionality of the circuits used. The first point concerns the rather wide range of selectivity that is made available through the use of the two I.F. channels. It is suggested that the best condition for ordinary purposes, and for searching, is the "455 kc/sec., Narrow" position. This is quite selective enough for most purposes, and so can be regarded as the "normal" operating condition for the set. If the two broader positions of the 455 kc/sec. channel are to be used, it is also a good plan to tune the signal accurately in the narrow position, setting the selectivity switch to the required position after this, and without touching the tuning control. In this way, one can always be certain that the tuning is correct, even in the broad position, and besides, the narrow position will give the sharpest indication of correct tuning for logging purposes. If the set is properly aligned in the first place, it will be found possible to switch to the 100 kc/sec. channel, after tuning accurately on 455, without having to adjust the tuning further. Should some very slight adjustment seem necessary, this can be done with the panel control on the 355 kc/sec. oscillator, but care should be taken when returning to the normal position, to re-set this control to its central position. After switching to the 100 kc/sec. channel, the main tuning should never be used to bring the signal on to the peak of this channel, since this will mis-tune it for the 455 channel. If, after switching to 100, the signal is not quite on the nose, this will be due either to inaccurate tuning with the main dial, or to the 355

(Continued on Page 48.)

The Philips Experimenter

(Continued from page 25.)

THE CIRCUIT

The circuit used in the original model is quite conventional, but there are one or two points about it that may repay a little consideration. First of all, it will be noted that no neutralization is used. It has been found that as long as suitable shielding precautions are taken, regeneration is small enough, even at two metres, to make neutralization unnecessary. The amplifier was found to be completely stable even when without a load on the plate circuit. However, it should be emphasized that unless the construction follows that used by us for the original, this will not necessarily be so, since it is important to have no appreciable feedback between the grid and plate tanks.

In order to provide a small amount of protective bias, a bypassed 100-ohm resistor is used in the cathode circuit, while the main grid bias source is the 25k. grid leak. There is, of course, no compulsion about the use of grid leak bias. Full cathode bias may be used, if desired, but in this case it will be necessary to use a double bypass on the cathode resistor if the stage is to be modulated. A 500 $\mu\mu$f. high-quality mica condenser should be used for R.F. bypassing, and as large an electrolytic as convenient should be paralleled with it for bypassing audio frequency components of the cathode current. For full cathode bias it should be remembered that the cathode will be at plus 100 volts when the stage is adjusted under load, so that two 50 μf. 50v. electrolytic condensers, in series, will be needed. Nor should the equalizing resistors across them be forgotten. These can have a value of 50k. each, and will prevent unequal leakages in the two electrolytics from causing unequal voltage distribution and possible breakdown.

For Class B linear operation, battery bias is strongly recommended unless plenty of driving power is available, to be dissipated in a swamping resistor connected across the grid circuit. In V.H.F. operation, the use of battery bias should be a considerable help in reducing the Class B driving power requirement.

Screen voltage is derived from the main H.T. supply by a dropping resistor, bypassed for R.F. but not for audio frequencies. This represents probably the most satisfactory method of applying simultaneous plate and screen modulation, since a special winding for the screen on the modulation transformer is not then needed.

In order to increase the plate efficiency, it will be noted that a very small plate tank condenser has been specified. This enables the stray capacity to be made very small if the component used is one of the midget Polar split-stator condensers. These have very low minimum capacities, and very low stray capacities from the frame to ground, owing to their small size. Thus, it has been possible to design the tank circuit for optimum Q, just as is done at lower frequencies, thereby ensuring that high plate efficiency is secured. One difficulty is that with midget condensers used in the plate circuit of an amplifier of this power, there may be some possibility of flash-over, owing to the small plate spacing. It is to minimize this possibility that the plate tank condenser's frame and rotor are connected to the H.T. line, thereby necessitating the insulation of the whole condenser from ground. This connection is helpful because it places only the R.F. voltages across the condenser. If the rotor were grounded directly, as is commonly done, it would be necessary to have a plate spacing that would withstand the D.C. plate voltage plus the peak R.F. voltage. We thus reduce the peak condenser voltage by the value of the H.T. voltage by using the connection shown. The rotor of the condenser still has to be earthed for R.F., however, but this is done by bypassing it with a 500 $\mu\mu$f. condenser. In theory, all this condenser has to withstand is the D.C. plate voltage, but it is good practice to use a high-quality mica condenser here, of about twice the rating that one would normally expect to be sufficient. It should be noted that the centre-tap of the plate tank coil is NOT bypassed to earth, but is left to "float" by the insertion of the R.F. choke. A common mistake in building circuits of this kind is to bypass *both* the condenser rotor and the centre-tap of the coil. Unless one is very lucky, such a procedure results in a badly unbalanced tank circuit, and thus in low efficiency and power output. In theory it should be possible to do this, but in practice it is almost impossible to ensure that the physical centre-tap of a coil is also its electrical centre, which accounts for the unbalance if both points are tightly earthed to R.F.

Next month we will continue the description with some discussion of the physical construction of the circuit, and some tips about operating it in the various conditions that have been outlined above.

(To be continued.)

CORRECTION TO ADVERTISEMENT

Swan Electric Co., January issue, inside front cover

It was incorrectly stated that the "E" type condensers were available from New Zealand stocks with 12 pF capacity swing. This should have read "438 pF swing."

Pre-Amplifier

(Continued from Page 8.)

The only undesirable thing about this response curve is that there is a rise just before the sharp drop. However, this rise can be counteracted by placing a small bypass condenser outside the feedback path of the amplifier stage. This gives just enough top cut to prevent the rise from occurring, and also has the advantage of making the unwanted rise after the null point much less pronounced. The final result is a curve in the shape of Fig. 3 which displays the rapid drop from the flat characteristic that we have been trying to achieve. By varying the values of the condensers in this circuit, the frequency at which the null occurs can easily be controlled. A five-pole, three-position switch is needed for this, because there are five condensers to switch, and we have decided on three selectable response curves. The switches are ganged by the simple expedient of making them of the wafer, wave-change type. Since each wafer will have two three-position switches on it, three wafers will be needed, giving a six-pole switch, one pole of which will not be wanted.

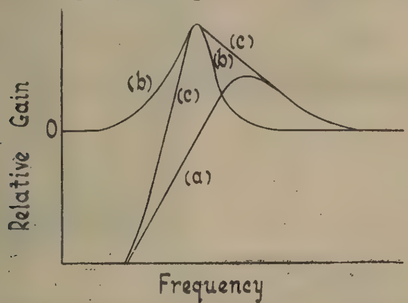
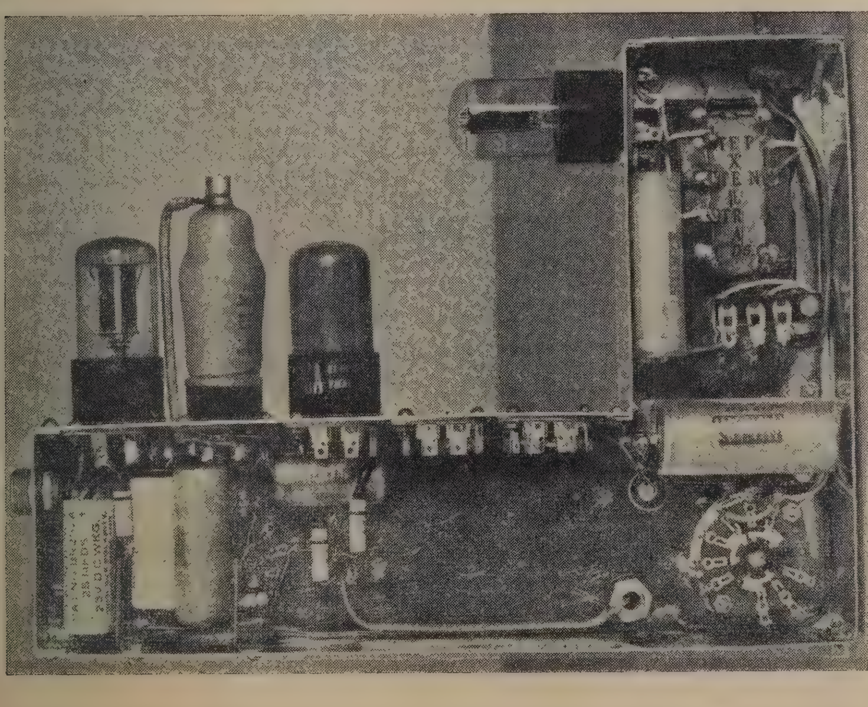


Fig. 4

From the above, it can be seen that though the circuit looks complicated, this is mostly on account of the switching, which really only adds to the number of parts shown on the diagram, and not really to the complexity. The output of V_2 is therefore (a) bass compensated, and (b) provided with a three-position switch which enables the full frequency response, or two different low-pass filters, to be selected at will to suit the record that is being played. This leaves only V_3 and V_4. The latter is merely the conventional cathode follower output tube, and requires no comment. V_3 provides amplification, and gives a high-pass filter that causes the response to cut off sharply below 20 c/sec. As can be seen from the diagram, the circuit of V_3 bears a considerable resemblance to that of V_2. This is because V_3 also has a parallel-T network connected as a feedback network between plate and grid. This time, though, there is only one network, and no switching, so that the circuit looks simpler. The really important difference is that in the case of V_3 the output is taken not from the output end of the parallel-T network, but from the plate of the valve itself. This gives us the well-known effect whereby the frequency characteristic of the amplifier becomes the inverse of that of the feedback network, and as a result, the circuit exhibits a sharp peak at the frequency of the network, instead of a null. This is shown as curve (b) on Fig. 4. Now the response of the rest of the circuit at low frequencies is like (a) on Fig. 4, and when these two curves are added together, the final result is as at (c) on the same figure. Thus we have the required bass boost down to 20 c/sec., after which the response drops away very sharply, and is about 30 db. down at 10 c/sec. This effectively removes the very low-frequency rumbles that are sometimes caused by gramophone motors, and sometimes are actually on recordings due to imperfections in the recording equipment.

It should be emphasized, however, that since the low-frequency cut-off is well below 50 c/sec., and because at 50 c/sec. there is considerable boost, it is essential for the amplifier to be as free of hum as possible. It is partly for this reason that comparatively elaborate precautions have been taken to ensure a completely hum-free H.T. supply. At the same time, the two sections of RC filtering after the main filter act as decouplers, isolating V_1 and V_2 from V_3 and V_4.



CONSTRUCTION

The unit is so constructed as to be as flat as possible, so that it can be placed on the shelf under the motor, and will then require a minimum of head room. In many cases it will be possible to install it in existing motor compartments, without the motor board having to be raised. The greatest

(Continued on Page 48.)

TRADE WINDS

Mr. E. G. Foster, Director of Electrical Supply Division, Cory-Wright and Salmon, is back from an extended trip to the United Kingdom.

* * *

J. W. (Jack) Ramsden who for the last few years has been the Wellington provincial representative for Russell Import Co. Ltd., has been transferred to Christchurch and will in future look after Russell's interests in the South Island.

Jack, who has been nearly 20 years in the radio and electrical industry, both in New Zealand and the United Kingdom, is looking forward to renewing acquaintance with all the "Mainland" retailers he met on his few trips down there during the year.

His aim is to give a service second to none and we feel sure Philco and all the other agencies Russell represent in New Zealand will be worthily represented in the South Island.

Retailers please note, his address will be 253 Weston Street, St. Albans, Christchurch.

* * *

Peter Tucker has resumed with National Electrical and Engineering Co. Ltd., and is looking after radio and 16 mm. projectors. Peter was one time assistant to Ivan Cosgrave in the same job and dealers are already familiar with Peter and his keenness for the dealers' welfare.

* * *

Amalgamated Wireless Valve Co., Australia, announce that soon to be released is the 1951 Radiotron Valve Data Book (5/-) per copy.

The many radio friends of Brig Mason, who since a few weeks before Christmas has been laid up in hospital, will be pleased to learn that he has reached the convalescent stage. Brig, who has an aptitude for farm life, is to spend some weeks on a farm at Featherston and will return to normal duties on the expiration of his sick leave at the end of March. Meanwhile Bill Lee is looking after the management of Wellington Branch of Swan Electric Co.

* * *

Much excitement with no little anxiety was caused through a fire at premises owned by Wellington Electronics and next door to that occupied by their own organization. Prompt response by the fire brigade saved what might easily have been a sensational conflagration. Wilf. Stent who discovered the outbreak had a harassing time and covered himself with soot if not glory.

* * *

Phil England until coming to Wellington as Sales Manager for National Electric and Engineering Co., was for 23 years prominent in Automobile Association affairs at Wanganui. His experience over these years is not to be lost to A.A. for he has recently been elected to the executive of A.A. Wellington.

* * *

Stan Shea, Tele-Communications Ltd., reports a hectic time over the holidays moving into new premises at Tory Street. Later he hopes to make up holiday leeway for a spell at Raumati South.

PUBLICATIONS RECEIVED

From Plessy International Ltd., television component brochure of 24 pages, containing much infomation of particular interest to designers.

From Central Office of Information, London, Bulletin No. 36, covering: One Hand Electric Soldering; Flexible F.M. Trans.-Receiver; Gas Tube Electric Detector; Valve Cheats Gravity; Heavy Duty Clip-on Ammeter; Bulk Viscosity Measurement.

From Swan Electric Co.: Technical Bulletin No. 7, Rola Magnet Winding Wire.

From G.E.C., Bulletin: Some Major Projects in Telecommunications.

CLASSIFIED ADVERTISEMENTS

WANTED SELL.—Two Power Transformer Winders. Good condition. Prices £30 and £40. Apply Radiart Company, 22 Brandon Street, Wellington.

THE NEW ZEALAND ELECTRONICS INSTITUTE (Inc.) NEWSLETTER

GENERAL

During the Christmas-New Year holidays, activities of the Institute have been somewhat restricted but it is hoped that during the forthcoming session activity will be more pronounced.

TELEVISION

In view of the interest being taken in television in New Zealand the following information which was received per courtesy of the Reciprocal Trade Federation of the United Kingdom should prove to be of interest to members. The information contained in the article was also made known through the courtesy of Pye Company, Cambridge, England, manufacturers of television equipment.

"What is Television? Programme Viewpoint

"To a person wishing to buy a television set, as to a country contemplating the installation of a TV transmitter, it is the programme possibilities which are a guiding feature. It has been calculated that there are at present about 400,0000 television receivers in use in the areas covered by Britain's transmitters at Alexandra Palace, London, and Sutton Coldfield, Birmingham, which brings the approximate number of viewers to one million. It is hoped that before the end of the year the number of television licence holders will have risen to 500,000.

"At Alexandra Palace there are at present two television studios, but new and large studio space has recently been acquired at Lime Grove, London, which will be used for special broadcasts—particularly during the Festival of Britain in 1951—as well as for children's programmes. When the B.B.C. obtained this studio they placed with Pye an order for television equipment to the value of £56,000 which included equipment for a new outside broadcast control vehicle, complete with ancillary equipment and five new image orthicon cameras—the finest and most modern yet designed, particularly suited to outside broadcasting.

"The programmes shown by the B.B.C. Television Service are divided into sections covered by various departments—drama, music, light entertainment, films, talks, documentaries, outside broadcasts, and, of course, children's programmes—all of which combine to bring variety into a week's viewing for young and old.

"The daily programme is divided into three parts: a morning broadcast consisting, perhaps, of a news reel and demonstration film for the benefit of the television trade; an afternoon broadcast of feminine interest—fashion or cookery—and including a programme for children of both educational and entertainment value which is now followed eagerly by children throughout the television area; and an evening programme covering a wide range of subjects.

"A weeks entertainment might include:

1. Two separate editions of the Television News Reel Film, each broadcast twice, as well as a special children's news reel, broadcast on two afternoons each week.
2. Two full-length plays of approximately 90 minutes (one of which is normally repeated to give everyone a chance to view).
3. Two variety shows.
4. A magazine programme introducing interesting personalities to the screen.
5. Various sports programmes, such as tennis, cricket, football, horse racing or jumping.
6. Ballet and opera, or events of public interest.

"TV Across the Sea

"The outside broadcast is really the most popular of all television features, whether this is a cricket match or public function such as the Royal wedding or the boat race.

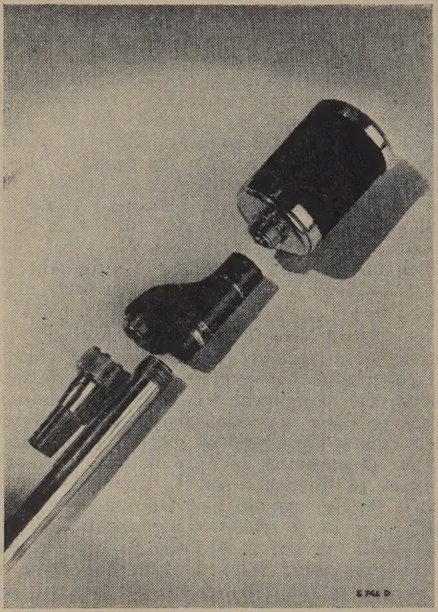
"Quite recently the B.B.C. organized a television transmission from Calais in France—across the twenty-two miles of the English Channel. For this broadcast it was necessary to set up five temporary radio link stations along the 95-mile route to London. In the tower of Calais Cathedral, a height of nearly 220ft. a micro-wave transmitter was installed to pass the signal to the station at Dover and on to Alexandra Palace, London, through the other link stations. For the benefit of viewers in the Birmingham area it was relayed to the B.B.C. television station at Sutton Coldfield. This was a great undertaking on the part of the B.B.C., and the pictures obtained in England of people in France were most successful.

"And Now TV from the Air!

"Pictures were recently transmitted by the B.B.C. from air to ground over London. The camera and portable transmission equipment was carried inside a Bristol Freighter, the door of which had been dismounted to enable the camera lens to look out over the landscape. Also in the programme as a miniature air display of various types of British aircraft. Viewers were shown the aircraft on the ground and were introduced to the pilots and crew by a television commentator. Then, as the planes took off and passed the Bristol Freighter in the air, pictures were relayed from the plane to the ground. In spite of the dull weather the pictures obtained were most successful."

NEW PRODUCTS: • LATEST RELEASES IN ELECTRICAL • AND ELECTRONIC EQUIPMENT

"RONETTE" CRYSTAL MICROPHONES



A complete range of microphones is shortly to come to hand from Ronette Company, Holland; distributors: Messrs. Green & Cooper, Wellington. The illustration describes model S742 cylinder type, of particular application for broadcasting of concerts, theatrical performances, etc. By a special construction the stand connecter can be unscrewed and the cell microphone can be suspended over the orchestra or speaker directly on cable-plug. Equipped with two "light weight" sound cell units with greatly reduced dimensions, the sound cell does not cause discrimination. Has high capacity bimorph crystal units, is plural moisture sealed, and has full automatic barometric compensation.

Fitted with Ronette stand connecter which is exactly the same as the American standard thread.

Technical details: Sensitivity: Equal sensitivity to all directions and for all frequencies. Frequency response from 20 to 14,000 cycles, flat plus or minus 3 db. Voltage: 1.5 mv/μB, measured between microphone terminals across 5 megohm load resistance at 100 cycles, equivalent to 56 db. below 1 volt per bar, measured by open circuit. Impedance: Equivalent to a 4400 pF capacity. Load resistance: 5 megohm recommended: Maximum working temperature: 120° F. or 50° C. Output level and cable length: 15, 30, and 60 metres. Output level at cable terminals: 59 db, 62 db, 66 db. Output level expressed in db below 1 volt p. bar. Net weight: 240 grammes.

Other models include B110: Torpedo type in plastic case, various colours. Low price range.

G310: Robust metal construction, with tilting head. Colours, dark grey, greyish green, etc. Medium price range.

R150: Of distinguished appearance, adjustable saddle. Also in medium price range.

Also available are Ronette Crystal Microphone Inserts and Ronette Crystal Pick-up Inserts.

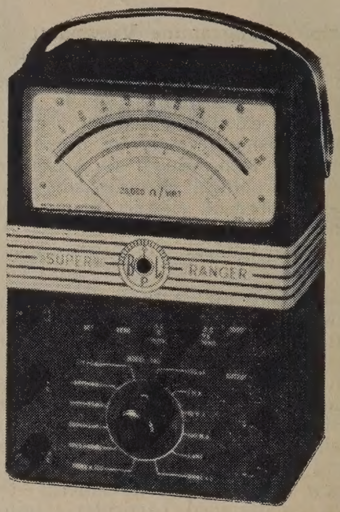
For full details of this "Ronette" shipment apply to New Zealand distributors, Green & Cooper, Ltd., Lower Taranaki Street, Wellington.

* * *

B.P.L. SUPER RANGER

20,000 Ohms/Volt

A precision instrument of pioneer design, by British Physical Laboratories (Instruments) Ltd., England, now available from Swan Electric Co. Ltd.



General description: The B.P.L. Super Ranger is a precision built instrument equipped with a fine 5 in. movement mounted in spring loaded sapphires. In order to fully exploit the high accuracy a mirror scale is incorporated.

The range selector, of sturdy construction, by means of which all ranges are selected except the A.C. current ranges and the 5,000 volts range.

The very high resistance of the voltage ranges, combined with the sensitive current ranges, makes this instrument particularly suitable for the servicing of electronic equipment and television receivers.

Both the electrician and the radio engineer will appreciate the provision of A.C. current ranges which, in conjunction with the other ranges will cover all measurements to be expected.

Specification:

D.C.

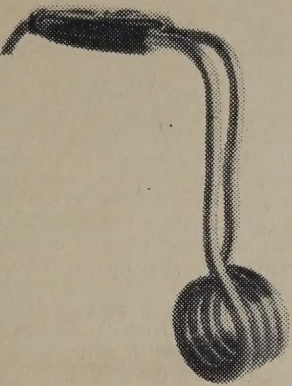
VOLTS	CURRENT	RESISTANCE
10	100 μA	0—20,000 ohms
50	1 mA	(1600 ohms half scale)
100	10 mA	0—2 megohm
500	100 mA	160,000 ohms half scale)
1000	1 Amp.	Both ranges with
5000		internal battery.

A.C.

VOLTS	CURRENT	OUTPUT
10	0.1 Amp.	0 db to 22 db
50	1 Amp.	14 db to 36 db
100	10 Amps	20 db to 42 db
500		34 db to 56 db
1000		40 db to 62 db
5000		

Resistance on all volt ranges 20,000 ohms per volt.
Dimensions: 6 in. x 8½ in. x 4 in. (deep).
Weight: 6 lb.

ULTIMATE IMMERSION HEATER



The Ultimate Immersion Heater pictured here is a fast heating water boiler of coiled copper tube type. The shaped neck enables the heater to be hung inside a water container, thus keeping the moulded phenolic terminal head outside the dangerous steam area.

Element permanently centralized in tube is of best quality nichrome wire and fully insulated by swaging tube after being packed with filler.

Heater is heavily plated to prevent contamination and yet gives maximum heat transference.

Rating: 1000 watts. Cord: 6 ft. flexible power cable. Retail price: 22s. 6d.

* * *

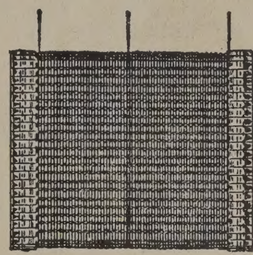
NEW ROLA SPEAKER—INVERTED ELLIPTICAL TYPE

Swan Electric Company Ltd. announce the production by Rola of an inverted speaker of special appeal to designers of mantel and portable receivers, and other special applications.

Described as Model 9–6H Rola, Australia's first inverted elliptical loudspeaker, its features include a diaphragm assembly and a driving system so placed that the overall depth of the speaker is only two inches, providing a speaker giving 8-inch results, yet taking up little more frontal space than a 6-inch unit and shallower than the standard 5-inch speaker. For illustration, etc., see advertisement elsewhere in this magazine.

* * *

"CRESSAL" ASBESTOS WOVEN RESISTANCE NETS, FLAT-RIBBON GRIDS TOROIDALLY WOUND POTENTIOMETERS AND SLIDING RESISTANCES



Messrs. Bradley's Electrical Company, Ltd., Wellington, who are the sole New Zealand agents for the Cressal Manufacturing Co., Ltd., Birmingham, England, advise that stocks are now available of a wide range of resistance nets and grids. Illustrated above is one of the grids the construction of which is unique in so far as that the actual resistance wire or ribbon is woven in with an asbestos twine making a resistance unit ideal for all purposes, being unbreakable, rigid and almost indestructible and having a maximum radiating and cooling surface in the smallest possible space. Standard ranges of resistance nets cover from 8 in. x 8 in. to 12 in. x 12 in. with an ohmic range of 8 ohms to 3600 ohms and a wattage range of 125 to 510. In the case of the flat ribbon grids, sizes range from 7 in. x 8 in. to 12 in. x 15 in. with a current capacity of 5 to 35 amps

continuous service or by connecting grids in parallel resistances carrying up to 350 amperes can be obtained. Special sizes, wattage, or resistance values are obtainable on request although Bradley's Electrical Co. Ltd. do carry a much wider range than listed above. Uses to which these units have been put are listed briefly—voltage controllers, motor starters, battery charging resistances, electroplating controls, air conditioning, laboratory test equipment, seed drying, laboratory ovens, fruit drying, plate warmers, convection heaters, chicken brooders, signal controls, transmitter dummy loads, and a multitude of other uses too numerous to mention. Each grid or net is provided with a wide selvedge enabling it to be mounted very easily without impairing its heat dissipating qualities.

Toroidally wound potentiometers of a very wide range are available. These units are wound on a heat resisting ceramic former by specially designed machines with the object of securing a perfectly tensioned and even winding which will not slip under full load continuous working conditions. Standard ranges in the 50-watt size are from three to 7800 ohms with a current capacity of four to .08 amps, in the 100-watt size resistances from three to 17,000 ohms and 5.8 to .08 amps are available. Each size is available in five to one slow motion drive or direct. Heavy duty sliding resistances, both open and totally enclosed types and wall mounting dimming resistances for theatres are also available. There is also a range of field regulator resistances for motors of all types.

Amateur TV

(Continued from Page 29.)

Again because of the high frequency, the tube which amplifies the cathode pulse from the gas tube is made a pentode; note also the low load resistor, of only 10k., and the decoupling network of 10k. and 8 μf. This is used so that the supply to the black-out pulse amplifier shall be as free of hum as possible, and also so that the plate current pulses will not feed back through the power supply to the other stages, and adversely affect their operation.

Because of the presence of a high cathode resistor in the amplifier stage, it is necessary to put a small positive voltage on the grids of the tubes so that they shall be properly biased. Without this voltage they would be considerably over-biased, and would distort badly at all output levels. This positive voltage is derived from the H.T. line via a voltage divider consisting of a 100k. and a 10k. resistor in series. There is no need to bypass the junction as long as the H.T. line is adequately filtered, but it is advisable to do so because this improves the decoupling between the two grids. The grid return of the first 6AC7 is taken to the voltage divider not directly, but through a filter comprising the two 8 μf. condensers and the 50k. resistor. This filter ensures that there is no signal feedback from one grid to the other, because the grid of the second 6AC7 should be at earth potential as far as signal is concerned. A large screen bypass condenser is not needed, because the amplifier stage has to handle only frequencies above 15,000 c/sec., and for the same reason, the grid coupling condensers can be quite small, likewise the condensers blocking the D.C. plate voltage from the deflecting plates.

Again for hum reasons, as well as for decoupling, a filter of 20k. and 8 μf. is placed in series with the plate resistor of the line EN31.

(To be continued.)

Communications Receiver

(Continued from Page 41.)

oscillator control not being set to its proper central position. However, the operator will soon become familiar with these controls and their interaction, and will have no difficulty in tuning so that the signal is properly tuned on both channels at once. When this condition is met, it is possible to switch from one channel to the other without touching any of the tuning controls. In searching for weak stations, it is frequently of assistance to use the 455 B.F.O. For this purpose, the B.F.O. can be adjusted to exactly 455 kc/sec., so that zero-beat represents proper tuning. To adjust the oscillator in this way, a signal is tuned in in the ordinary way, with the help of the S-meter, and the B.F.O. is then turned on, and adjusted until it is at zero beat with the received carrier. Should a beat note be desired when the signal is in tune, as is the case for C.W. reception, the best procedure is to tune in a continuous carrier, using the S-meter as an indication of proper tuning, and then adjust the B.F.O. to the desired beat note. It may then be desired to adjust the B.F.O. for the 100 kc. channel so that when the channel switch is operated, the same beat note is heard. This can be done as follows. A steady carrier is tuned in accurately on the 100 kc/sec. channel, with the 355 oscillator trimmer at its usual central position. Then, without touching the main dial, the channel switch is turned to 455, and the B.F.O. is then turned on, and adjusted to a suitable beat note. Then, the channel switch is turned back to 100 kc/sec., and the 100 kc/sec. B.F.O. tuning is adjusted until the beat note is the same as the one produced on 455 kc/sec. With the receiver set up like this, it will be possible to change from one channel to the other at will, knowing that the same signal is being received on both.

It will be found that with the 100 kc/sec. selectivity control working properly, there is no change of tuning at all, and that virtually noiseless C.W. reception can be had simply by advancing the selectivity knob until the background disappears. The 100 kc/sec. channel will split signals that the sharpest 455 kc/sec. amplifier (without a crystal filter) will not separate, but with the advantage that no critical adjustments have to be made. The selectivity is merely increased with the control until the desired degree of selectivity is obtained.

The End.

Pre-Amplifier

(Continued from Page 43.)

height of the unit is just under four inches, and this occurs in such a position that it is well away from the underhang of the motor. In the centre of the motor compartment, the height is only 1¼ in.—the height of a valve lying on its side! The L-shaped chassis is intended to mount in the corner of the motor compartment, so that the control shafts come up clear of the motor, and so that the highest components are also clear. The lowest part of the motor is usually somewhere near the centre of the compartment, so that in allowing space for the pre-amplifier in a new arrangement, only 1¼ in. need be allowed for the height of the unit in the centre. It would have been possible to mount the valves upright on the chassis, but this would not have made nearly as much space available inside for the rather large number of small components that have to be fitted in. Putting the valve sockets on the side of the chassis leaves almost the whole of the underneath free for accommodating these parts.

(To be continued.)